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COMPLETE DENTURES
REMOVABLE PARTIAL DENTURES
FIXED PARTIAL DENTURES
OPERATIVE DENTISTRY

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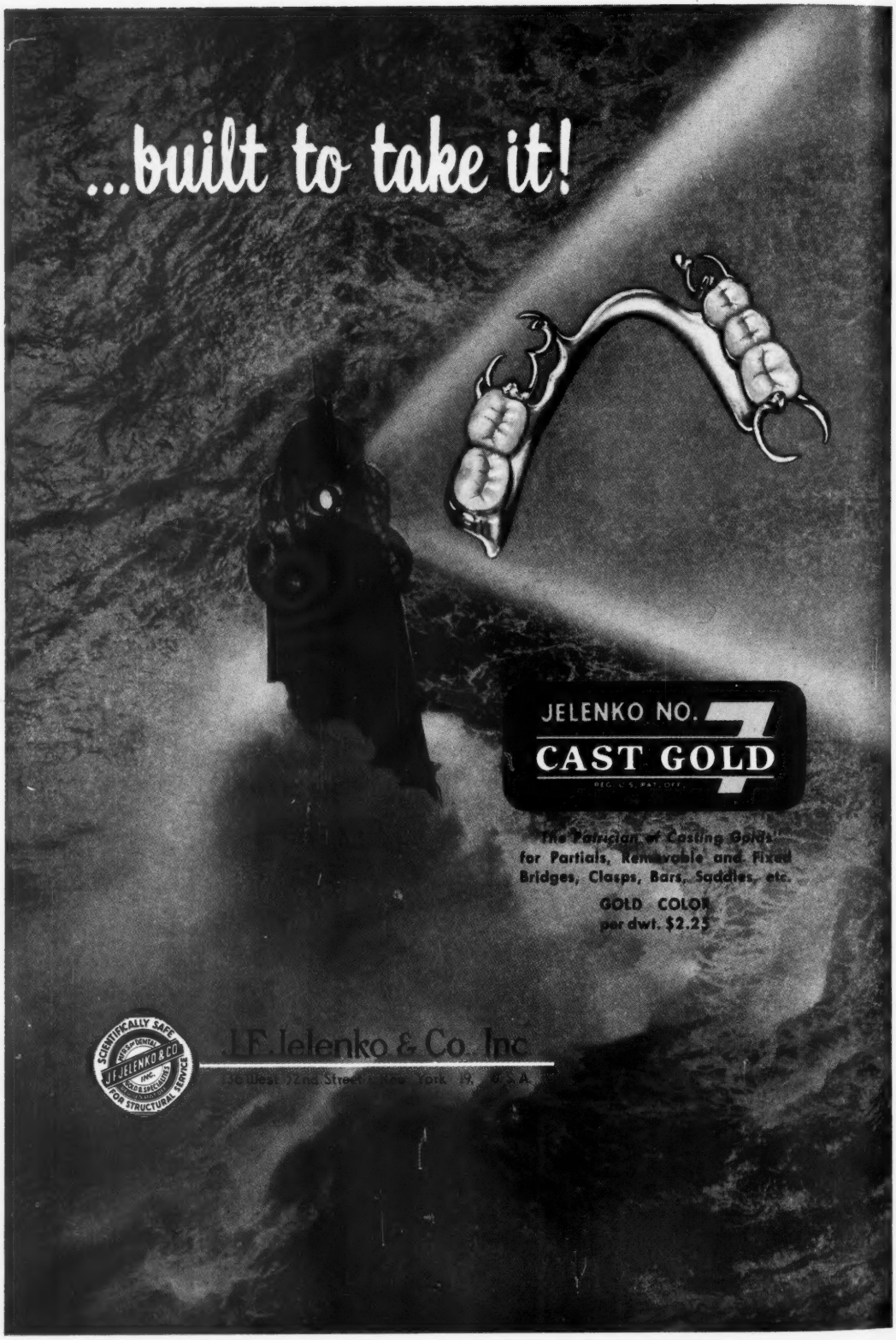
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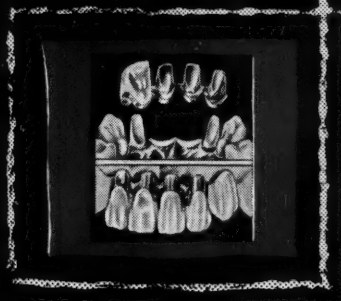

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THROUGH THE EYES OF THE EDITOR

Finn Tengs Christensen discusses the relationship between the protrusive inclines of cusps and the condylar guidance. He shows by mathematical analysis and formulae the relationship of these tooth inclines which is necessary if continuous harmonious contact is to be maintained on all posterior teeth during a forward protrusive gliding movement. While these computations are not necessary for the practical arrangement of teeth on dentures, an understanding of them will make the setting of teeth into balanced occlusion much easier. His consideration of the length of the protrusive movement in the determination of the cuspal angle seems to be particularly significant.

Paul A. Miller calls attention to a very serious problem in prosthodontics and suggests a solution to it. Too many young people are inclined to allow their teeth to deteriorate until they are almost beyond repair with the mistaken idea that their dental troubles will be over when they have dentures. While this may be true for a few years, time and bone resorption will catch up with them eventually. In the later years of their lives, they will become problem patients so far as denture wearing is concerned. The technique suggested will help to retard the shrinkage of the bones which are the foundation for dentures. The remaining teeth will delay the conversion of alveolar bone into a residual ridge.

G. A. Lammie, H. T. Perry, Jr., and B. D. Crumm continue their report of observations on a complete denture patient. The effects of six sets of dentures built with different horizontal and vertical maxillomandibular relations were studied by means of electromyography while the patient chewed various test foods. Their observations shed further light on the power and adaptability of the muscles of mastication under different experimental conditions and seem to confirm clinical observations.

F. M. Lose describes a method for easy identification of dentures by including a record of the patient's name and the mold and shade of the teeth within the denture base. While the method is not new, it would provide an additional service to the patient, in case of an accident to the denture, and to the community, in case of a tragedy.

Alexander L. Martone discusses the treatment planning for partially edentulous patients. His approach to the problems is different from that usually expressed in the literature. His objective is to treat not only the existing conditions but to plan for possible future deterioration of the patient's oral structures. This is done on the basis of consideration for the weak elements of the remaining parts of the dentition. Obviously, this approach has as one of its major objectives an honest concern for the economics of partial denture treatment from the standpoint of the patient. It is another step away from simply restoring the missing teeth and toward a long term treatment plan for each patient. He recognizes that, in spite of our best efforts, accident and disease can cause the loss of teeth other than those which are treated initially. He suggests designs for partial dentures which

can make their modification simple and, thus, extend the usefulness of the restorations. The application of these principles should go far toward developing good public relations by illustrating the sincere interest of the profession in the people it serves.

William L. McCracken discusses functional occlusion in relation to partial denture construction and describes a method for developing a balanced occlusion between these restorations and the opposing occlusal surfaces. The importance of balanced occlusion to the maintenance of health in the mouths of patients wearing partial dentures has been overlooked in many instances. The remaining teeth and the residual ridges may both be damaged by a failure to balance the occlusion properly. The procedure he suggests is a modification of the technique suggested by Dr. Frederick S. Meyer. The occlusal paths generated by the cusps of the opposing teeth are preserved by electroplating the surface of the wax record. This should lead to greater accuracy. The only apparent disadvantage is in the possible mutilation of the occlusal surfaces of the teeth on the restoration.

Robert E. Herlands reports the studies of the terminology used in partial denture prosthodontics by a committee of the Greater New York Academy of Prosthodontics. The report points up the need for a constant reappraisal of the words used by the dental profession. Too often dentists allow themselves to use a word incorrectly or abbreviate terms unnecessarily. This habit leads to misunderstanding when incorrect terms get into print. Abbreviations, such as "upper bi" for upper bicuspid, "vertical" for vertical dimension, or "centric" for centric relation or centric occlusion are not precise, and they do not lend dignity to our speech or literature. They are not in keeping with the present scientific development of dentistry. This report suggests terms and definitions which are worthy of study and consideration by the entire profession, and all committees concerned with nomenclature should examine them critically. If they stand the test of this type of scrutiny, they should be adopted in the interests of universal understanding. If not, new terms or definitions should be proposed for study.

Nathaniel H. Lenchner, Martin Handlers, and Bernard Weissman describe their modified retaining device and report on its use over a period of three years. The modifications seem to overcome some of the difficulties encountered with the previous model, and the report points out the advantages of this type of retention for partial dentures.

H. Milton Rode discusses the teaching of gnathology to undergraduate students at the University of Pennsylvania. He reports that the students have a greater interest in occlusion than those who have been taught the usual methods and procedures. If this interest can be maintained after graduation and if dentists trained in this philosophy will apply the principles involved in their everyday practice, tremendous improvement in prosthodontics could result. However, if these students follow the example of too many others, the improved results will not be as lasting as is hoped. Unfortunately, too many dentists are looking for "shortcuts" and are not practicing as well as they know how, even now. It will be interesting to follow this experiment in dental education.

David J. Baraban discusses the temporary cementation of fixed partial denture prostheses with zinc oxide-rosin-eugenol cements. He points out many advantages of the procedure and describes the conditions under which it should be used. His emphasis upon the necessity for frequent inspections after cementation seems to be warranted. He suggests tests for the effectiveness of the cementation and feels that these are essential to the use of the procedure. If it is used intelligently, it can serve a useful purpose for many patients.

Ralph W. Phillips and Richard J. Schnell compare the accuracy of dies made in impressions made from different elastic impression materials. They compare the results obtained with different metalizing materials for electroplating with silver and copper. They found surface defects and distortions which indicate that the electroformed dies do not reproduce the original model as accurately as stone dies, even though the dies were "clinically acceptable." They recommend different electroplating procedures for each of the different impression materials.

Howard J. Frankel discusses the uses of autopolymerizing acrylic resins in fixed partial denture prosthesis and describes his techniques for making transfer copings and temporary restorations. These materials and

techniques make it possible to overcome some difficulties which have been annoying.

Harold C. Kilpatrick makes another progress report on the techniques for using ultra-high speed rotational instruments in operative dentistry. He classifies the various instruments of this type which are currently available and compares their effectiveness for different operations. He recommends specific cutting instruments for each step in the preparation of cavities. This emphasizes the importance of an orderly procedure in these dental operations for economy of time and effort.

George A. Ellsperman discusses some fundamental procedures in gold foil operations and describes parts of the technique which are critical to either the success of the restorations or to speed in building them. He emphasizes the importance of standardizing the procedures by the individual dentist and his assistant in order to obtain uniformly good results in a minimum of time.

Alexander S. Forster urges that dentists "become specialists in the practice of good dentistry." In order to assist them in this direction, he discusses certain techniques which are applied by specialists and which can be applied easily by general practitioners. He emphasizes the operations which make dental service more pleasant for the patient and less taxing upon the dentist.

Allison G. James reviews and compares the various types of high-speed operative instruments. He calls attention to the fact that high rotational speeds are not necessarily the equivalent of speedy cavity preparation. There are coincidental dangers and difficulties to be encountered with these instruments, especially if they are not used correctly. He emphasizes the importance of adequate training, care, and experience in their use and foresees much damage to patients and to the reputation of the dental profession if dentists using this new equipment do not use it correctly.

E. J. Fredrickson discusses the use of button type tissue implants as a means for retaining maxillofacial prostheses in certain situations. The procedure may seem to be radical but the problems of retention of surgical prostheses often require the use of techniques which may not be most desirable. The method he describes appears to be effective if it is used correctly where it is indicated.

Ralph W. Flinchbaugh describes the techniques he used for the construction of a hemimandibular implant. Patients subjected to hemisection of the mandible suffer severe facial deformities unless this type of construction is carefully planned and executed *before* the surgical treatment is carried out. This calls for the ultimate in cooperation between the surgeon and the prosthodontist.

Arthur S. Freese describes his equipment and technique for making temporomandibular joint roentgenograms. The apparatus is ingenious and it has some apparent advantages over some other devices. The results seem to be very good.

Ralph W. Stacy, Judson C. Hickey, Julian B. Woelfel, and Lloyd Rinear discuss the use of electromyography in dental research. They compared the recordings made by different recording devices and methods of analyses of these records with due consideration for the frequencies being recorded. They conclude that pen recording should be supplemented by other types of records and methods of analyses. This should avoid errors in interpretation which could lead to incorrect conclusions about the muscular activity involved in jaw movements and mastication.

—*Carl O. Boucher*

COMPLETE DENTURES

CUSP ANGULATION FOR COMPLETE DENTURES

FINN TENGS CHRISTENSEN, L.D.S.*
Stavanger, Norway

THE OBJECTIVE OF THIS article is to clarify the relationship between the sagittal cusp angulation and the inclination of the condylar guidance. It will show how steep the mandibular protrusive facets should be in order to maintain full antagonist contact along the entire length of the protrusive facets by a protrusive sliding movement, without using any inclination of the incisal guidance or a compensating curve. In order to understand the relationship between the inclination of the condylar guidance and the cusp angulation, it is important to clarify the theory of the Christensen phenomenon. Using occlusion rims with flat occluding surfaces, a wedge-shaped cleft is formed between the posterior part of the occlusion rims during a forward protrusive movement. This is due to the forward and downward movements of the condyles. The fact that such a cleft occurs, under the above-mentioned conditions, is called the Christensen phenomenon. The projection on a sagittal plane of the angle between the occlusion rims in connection with the Christensen phenomenon is called the Christensen angle in this investigation (Fig. 1).

The Danish professor, Carl Christensen,[1] was probably the first to describe the relationship between the above-mentioned cleft and the inclination of the condylar guidance. Further, he showed that the cleft can be used as a measurement of the inclination of the condylar path of the patient, which could then be transferred to an articulator with an adjustable guidance mechanism. When Christensen published his article in 1901, it was already known that it was possible to measure the inclination of the condylar path. Walker[2] had published an extraoral measuring technique in 1897 which was very complicated and, therefore, unsuitable for practical use.

The interesting point regarding Christensen's method was the simple measuring system, i.e., that the inclination of the condylar path can be adjusted by means of a wax interocclusal record made at a forward protruded position of the mandible.

THE CHRISTENSEN DISTANCE

The distance between the occlusion rims increases in size from the front toward the molar region by the amount of the Christensen angle (Fig. 2).

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*Assistant Professor, Norwegian State Dental School, Oslo, Norway.

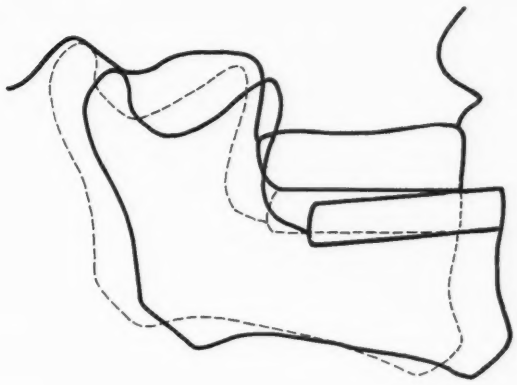

Fig. 1.—The Christensen phenomenon (after Gysi).

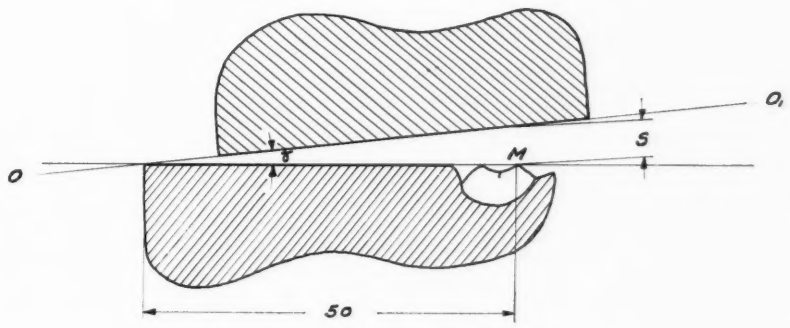

Fig. 2.—The Christensen angle (γ) and the Christensen distance (S_m) at the distobuccal cusp of the last mandibular molar

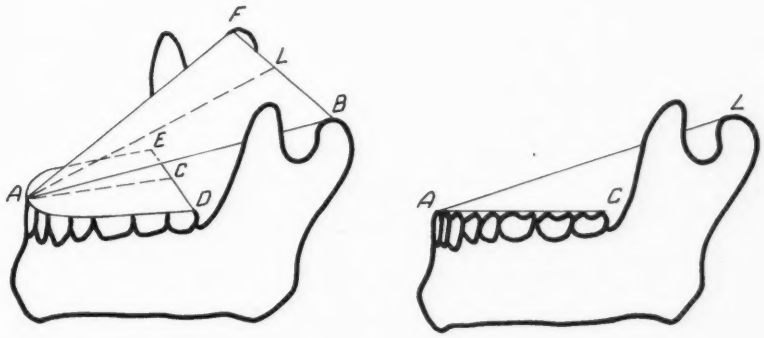

Fig. 3.—Bonwill's triangle *ABF* and Balkwill's angle *CAL*.

The distance from a point (*M*, Fig. 2) on the mandibular occlusion rim to a point perpendicular to the maxillary occlusion rim is called the Christensen distance. This distance in the premolar region is thus smaller than in the molar region. The Christensen distance (*S*, Fig. 2) is found by multiplying the sine of the Christensen angle (γ) by the distance from the incisal point to the point in question from which the Christensen distance is to be measured (*M*, Fig. 2).

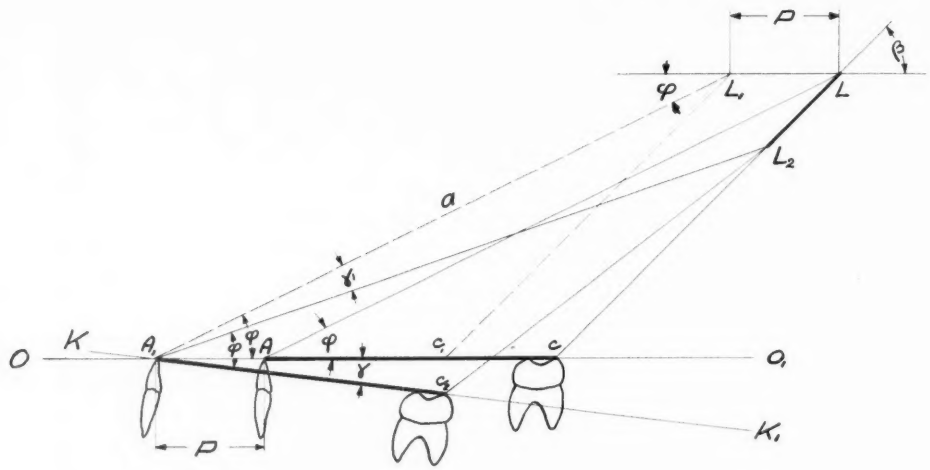

Fig. 4.—Schematic reproduction of the relation between the incisal point *(A)*, the summit of the distobuccal cusp of the last mandibular molar *(C)*, and the condylar axis *(L)*. The projection is in the median plane. Centric occlusion is represented by *ACL*, protrusive relation by $A_1C_2L_2$.

a, The height of Bonwill's triangle, that is, the perpendicular from the incisal point to the condylar axis = $AL = A_1L_1 = A_1L_2$.

A-A1, The size of protrusion, that is, the length of the ventral movement of the incisal point by protrusive movement = $LL_1 = C\,C_1 = p$.

A-L, See *a*.

A1-L1, Auxiliary line, parallel-shifting of the line *AL*, ventral displacement by a condylar guide inclination (β) = 0 degrees.

β, Condylar guide inclination.

C, The tips of the distobuccal cusps of the last mandibular molar in the centric occlusion.

C2, The tips of the distobuccal cusps of the last mandibular molar after protrusive movement.

γ, The Christensen angle = γ_1.

K-K1, The mandibular plane of occlusion after protrusive movement.

L-L1, See *A-A1*.

L-L2, The length of the movement of the condylar axis in the condylar path by a movement of the incisal point from *A* to A_1.

O-O, The plane of occlusion.

p, See *A-A1*.

, Balkwill's angle.

Assuming this distance to be 1, the Formula for the Christensen distance is:

$$S = 1 \text{ sine } \gamma \text{ (Formula I)}$$

where γ is the Christensen angle.

Taking the occlusal relief sagittal length as 50 mm., the Christensen distance at the end of the occlusion rim can be expressed by the formula:

$$Sm = 50 \text{ sine } \gamma$$

CALCULATING THE SIZE OF THE CHRISTENSEN ANGLE

In order to calculate the Christensen distance and, thus, measure the height of the cusps, it is necessary to determine the size of the Christensen angle.[3] To simplify the calculation concerning the Christensen angle, the sides of Bonwill's triangle (Fig. 3, *AFB*) are assumed to be 100 mm. (properly 4 inches).[4] Bonwill's triangle is an equilateral triangle, the angles of which are formed, respectively, by the incisal point and the two mandibular condyles. The height in Bonwill's triangle (*a* in Figs. 4 and 5) is 100 mm. × sine 60 degrees. In clinical work, it will prove advantageous to make the dorsal line of Bonwill's triangle identical with the condylar axis.

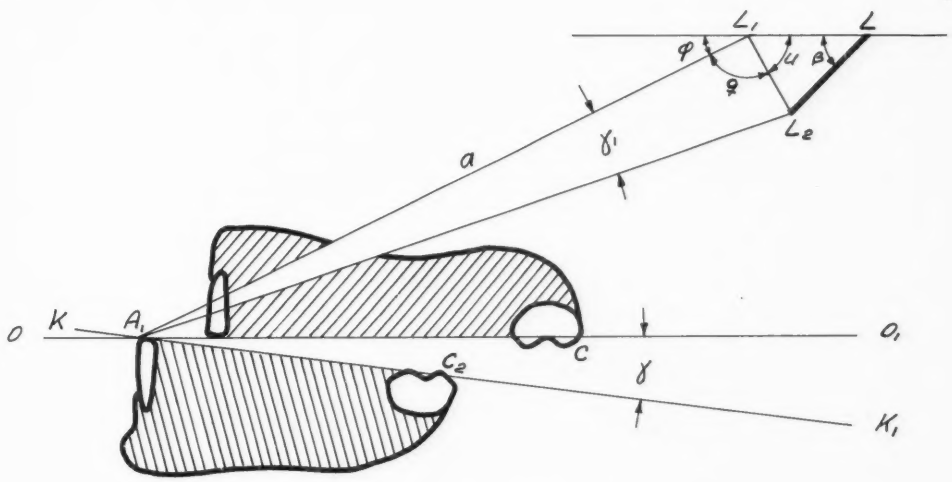

Fig. 5.—Simplication of Fig. 4. Some auxiliary letters are added.

It is assumed that the line which forms the dorsal limit of Bonwill's triangle coincides with the condylar axis and that this line is perpendicular to the median plane. The plane in which Bonwill's triangle is situated is called Bonwill's plane. The Balkwill angle is the angle between the plane of occlusion and Bonwill's plane projected on the median plane (Fig. 3, *B*). This angle, according to Balkwill's calculations,[5] is assessed at an average equal to 26 degrees. The calculations of the Christensen angle in this investigation are based on the following assumptions:

The condylar path is *straight,* and the inclination of the condylar guidance is identical on *each side.*

By inclination of the condylar guidance is meant the inclination of the sagittal condylar guidance to the *plane of occlusion,* which is an imaginary plane, passing through the incisal point and the tips of the distobuccal cusps of the last molar on each side.

By *protrusion* is meant *forward* protrusion, and when using protrusive movements in connection with the Christensen angle, the incisal point is assumed to be displaced into, or parallel with, the maxillary occlusion rim (Fig. 4, where $A—A_1$ is on the line $O—O_1$).

Assuming the lower jaw (*ACL*, Fig. 4) to be protruded forward along the plane of occlusion ($O—O_1$) a distance equal to the length of the protrusion (*P*), this distance equals a movement of A to A_1 and L to L_1 with an inclination of the condylar guidance of 0 degrees. The new position of the lower jaw becomes then $A_1C_1L_1$ (Fig. 4). The Christensen angle (γ) is found by allowing this triangle to rotate on the incisal point A_1 (Figs. 4 and 5), so that point L_1 (the projection of the condylar axis) comes into contact with the condyle path LL_2. L is thus displaced to L_2 and C_1 to C_2. It is clearly seen from Fig. 5 that the Christensen angle γ equals γ_1. A number of additional letters are added to Fig. 5 for extra clarity. From Fig. 5, through a series of mathematical calculations, Formula II is developed:

$$\text{sine } [(\beta \div \varphi) \div \gamma] = \text{sine } (\beta \div \varphi) + \text{p/a sine } \beta$$

Using this formula, the Christensen angle (γ) can be calculated using various inclinations of condylar guidances (β) and different sizes of Bonwill's triangle (a) and Balkwill's angle (φ). Similarly, we are able to calculate γ for protrusions of varying length (*p*). In Table I, the Christensen distance at the distobuccal cusp of the third molar (S_m) is calculated using Formula I.

TABLE I. THE CHRISTENSEN ANGLE

β	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°
γ	0.30°	0.60°	0.87°	1.14°	1.40°	1.66°	1.92°	2.20°	2.50°	2.80°	3.15°	3.53°
S_m	0.25	0.50	0.72	0.95	1.15	1.38	1.59	1.82	2.07	2.32	2.61	2.93

Christensen's angle by 5 mm. of protrusion (*p*), according to the formula, is:

$$(\text{sine } [(\beta \div \varphi) + \gamma)] = \text{sine } (\beta \div \varphi) + \text{p/a sine } \beta$$

Balkwill's angle (φ) = 26 degrees.
The height (a) in Bonwill's triangle = 86.60 mm.
β = condylar guide inclination.
γ = the Christensen angle.
S_m = the Christensen distance in millimeters at the tip of the third molar's distobuccal cusp.

By plotting the graph of Table I (Fig. 6), the size of the Christensen angle (γ) can be read on the left vertical column (ordinate) of the table at a protrusion of 5 mm. The ordinate on the right gives the Christensen distance at the distobuccal cusp of the third molar. The abscissa gives the size of the condylar guide inclination (β).

As is shown by Table I, the size of the Christensen angle *does not* increase proportionally with the inclination of the condylar path. The difference is small and is shown in the graph of Table I as a slightly curved line connecting those points which define the size of the Christensen angle (Fig. 6). This same curve shows that the Christensen angle is *relatively* smallest at 25 to 30 degrees. This phenomenon is due to the Balkwill angle.

According to Table I, the Christensen angle increases by approximately 0.5 to 0.6 degrees for every increase of 10 degrees in the inclination of the condylar

path with a protrusion of 5 mm. *Thus, a variation of 1 degree in the Christensen angle results in a difference of 15 to 20 degrees on the condylar guidance on the articulator when measuring the condylar path inclination by 5 mm. of protrusion.*

CHRISTENSEN'S ANGLE WITH PROTRUSIONS OF VARYING LENGTHS

Table I is calculated for a protrusion measuring 5 mm. For protrusions other than 5 mm., the Christensen angle will not be the same as that given in Table I. Table II shows the way in which the Christensen angle increases with various protrusions. Two different values for the angle of the condylar guidance have been chosen, 15 degrees and 45 degrees, respectively. The method of calculation is the same as for Table I.

It is clear from Table II and the graphic reproduction (Fig. 7) that Christensen's angle increases almost proportionally with the length of the protrusion. With a condylar guidance angle of 15 degrees, it increases, according to Table II, by 0.17 degree to 0.18 degree per millimeter of protrusion. With a condylar guidance angle of 45 degrees, the corresponding values are approximately 0.50 degree per millimeter of protrusion.

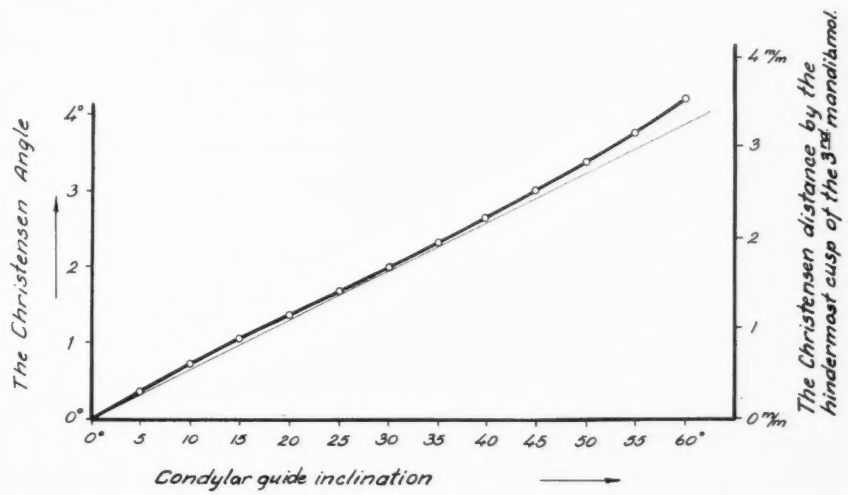

Fig. 6.—Graphic reproduction of Table I. The graph shows the Christensen angle by 5 mm. of protrusion and average values for Bonwill's triangle and Balkwill's angle. The line connecting the dots forms a flat curve. The value of the Christensen angle is relatively smallest by condylar guide inclinations that are about 25 to 30 degrees.

The calculation of the Christensen's angle with varying lengths of protrusion and a constant condylar guidance angle can be expressed by Formula III:

$$\gamma_x = \gamma_1 \cdot p$$

where γ_x is the desired angle, and γ_1 is Christensen's angle using a protrusion equal to 1 mm., and p is the length of the protrusion expressed in millimeters. If Table I is combined with the results of Table II, that is, that Christensen's angle increases proportionally with increasing forward displacement, Table III and the graphic

reproduction of Table III (Fig. 8) are obtained. For example, with a condylar guide angle of 45 degrees and a forward protrusion equal to 7 mm., Christensen's angle as taken from Table III is 3.5 degrees. If the condylar guide angle equals 20 degrees and the forward protrusion equals 6 mm., Christensen's angle equals 1.37 degrees.

TABLE II. THE CHRISTENSEN ANGLE WITH VARIOUS LENGTHS OF PROTRUSION

β \ p	1 mm.	2 mm.	3 mm.	4 mm.	5 mm.	6 mm.	7 mm.	8 mm.	9 mm.	10 mm.
15°	0.18°	0.35°	0.53°	0.70°	0.87°	1.05°	1.22°	1.40°	1.57°	1.75°
45°	0.50°	0.99°	1.50°	2.00°	2.50°	3.00°	3.51°	4.01°	4.52°	5.04°

β = condylar guide inclination.
p = protrusion.

CALCULATING THE CUSP ANGLES

In order to obtain a smooth running balanced occlusion, the factors effecting it must be in relationship to each other. This relationship is expressed in Hanau's Quint.[6] It is expressed even more clearly by means of Thielemann's articulation formula.[7] In Anglo-Saxon and Scandinavian literature, the formula is usually expressed in the following way:

$$\frac{K \cdot I}{op \cdot C \cdot ok}$$

where: K = Condylar guide inclination
I = Incisal guide inclination
C = Height of the cusps
op = The inclination of the plane of orientation
ok = The prominence of the compensating curve.

Thielemann uses other symbols more appropriate to the German terminology.

This formula expresses the cusp height C as a function of K and I, so that an increase in K or I is compensated for by an addition in C when op and ok are unchanged. The slope of the occlusal plan (op) is a step toward the determination of the condyle path angle. The compensating curve (ok) is assumed to be a straight line, and the incisal guide angle is taken as equalling 0 degrees. Therefore, these factors, namely, the inclination of the incisal guidance, the inclination of the plane of orientation, and the prominence of the compensating curve, can be eliminated by the above calculations, and Thielemann's formula can for this purpose be simplified to:

$$\frac{K}{C}$$

that is, the cusp height must be in relation to the condylar guide angle in order

to ensure a smooth running balanced occlusion. On the basis of the inclination of the condylar guidance, the Christensen angle and the Christensen distance can be calculated (Table I). On the basis of the Christensen distance, the cusp height and, thus, the cusp angle can be calculated.

It is the sagittal cusp angles at the buccal cusps which are calculated, but the same factors are used in the calculation of the lingual cusps.

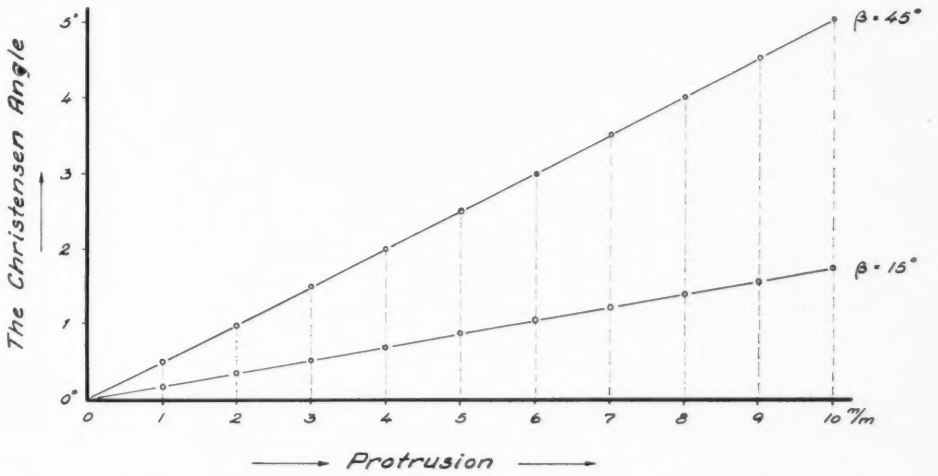

Fig. 7.—Graphic reproduction of Table II. The graph shows the size of the Christensen angle by various lengths of protrusion in connection with condylar guide inclinations (β) of 15 and 45 degrees, respectively.

In the following calculations, the sagittal length of the mandibular plane of occlusion is assumed to be 50 mm. The sagittal aspect of the occlusion is divided into 10 equal divisions (Fig. 9), each of which measures 5 mm. Each segment is assumed to equal the sagittal length of one cusp. Each of the buccal cusps, therefore, takes up 1/10 of the total sagittal length of the occlusion. The basis for this division was found by Mühlreiter[8] who gives the sagittal length of the mandibular occlusion profile as 48 to 52 mm. Bolk (Mühlreiter[9]) examined 7,800 molars and premolars of the inhabitants of Amsterdam. According to Bolk, the following measurements are the averages for the mesiodistal lengths of mandibular molars and premolars:

First premolar	(P_1)	6.6 mm.
Second premolar	(P_2)	6.9 mm.
First molar	(M_1)	11.1 mm.
Second molar	(M_2)	10.7 mm.
Third molar	(M_3)	10.7 mm.

The Christensen distance on Table I (S_m) refers to the distobuccal cusp of the third molar. It is calculated after assuming a protrusion of 5 mm. In order to ensure complete antagonistic contacts along the entire length of the protrusion facets of the teeth during protrusive movements, all corresponding cusps must be in contact by a sagittal displacement equal to half the cusp length, i.e., 2.5 mm.

TABLE III. THE CHRISTENSEN ANGLE BY DIFFERENT LENGTHS OF PROTRUSION AND VARIOUS CONDYLAR GUIDE INCLINATIONS

p \ β	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°
1 mm.	0.06	0.12	0.19	0.23	0.28	0.33	0.38	0.44	0.50	0.56	0.63	0.70
2 mm.	0.12	0.24	0.38	0.46	0.56	0.66	0.76	0.88	1.00	1.12	1.26	1.40
3 mm.	0.18	0.36	0.57	0.69	0.84	0.99	1.14	1.32	1.50	1.68	1.89	2.11
4 mm.	0.24	0.48	0.76	0.92	1.12	1.32	1.53	1.76	2.00	2.24	2.52	2.82
5 mm.	0.31	0.62	0.87	1.14	1.39	1.66	1.92	2.20	2.50	2.80	3.15	3.53
6 mm.	0.37	0.74	1.06	1.37	1.67	1.99	2.30	2.64	3.00	3.36	3.78	4.23
7 mm.	0.43	0.86	1.25	1.60	1.95	2.32	2.68	3.08	3.50	3.92	4.41	4.93
8 mm.	0.49	0.98	1.44	1.83	2.23	2.65	3.06	3.52	4.00	4.48	5.04	5.64
9 mm.	0.55	1.11	1.64	2.06	2.51	2.98	3.45	3.96	4.50	5.04	5.67	6.35
10 mm.	0.62	1.24	1.74	2.28	2.78	3.32	3.84	4.40	5.00	5.60	6.30	7.06

β = condylar guide inclination. p = protrusion.

The cusp height *(C)* for the distobuccal cusp at the third molar *(C M_3d)* should be half of the Christensen distance (S_m, Table I), since the cusp height is calculated assuming that the protrusion equals 2.5 mm.

According to the "Glossary of Prosthodontic Terms,"[10] *the cusp height* is "the shortest distance between the summit of a cusp and its base plane" (*Kh,* Fig. 10), and *the cusp angle* is defined as "the angle made by the sides of a cusp with the plane which passes through the summit of the cusp and which is perpendicular to a line bisecting the cusp, measured mesiodistally or buccolingually" (ϵ, Fig. 10).

In accordance with Fig. 7, tangents to the cusp angle (ϵ) are like $\frac{BG}{AG}$, where BG = half of the Christensen distance *(S)* by 5 mm. of protrusion, and AG = 2.5 mm. Consequently, tangents to the cusp angle

$$(\epsilon) = \frac{BG}{AG} = \frac{\frac{1}{2}S}{2.5} = \frac{S}{5} = \frac{S}{p}.$$

$$\text{tg.}\,\epsilon = \frac{S}{p} \text{ (Formula IV)}$$

That is, *tg. to the cusp angle is equal to the Christensen distance divided by the corresponding length of protrusion.*

From the incisal point to the summit of the distobuccal cusp of the third molar, the distance is 50 mm. − 2.5 mm. = 47.5 mm. According to Formula I, the Christensen distance *(S)* for the distobuccal cusp of the mandibular third molar = 47.5 mm. sine γ, where γ is the Christensen angle. By means of Formulas I and

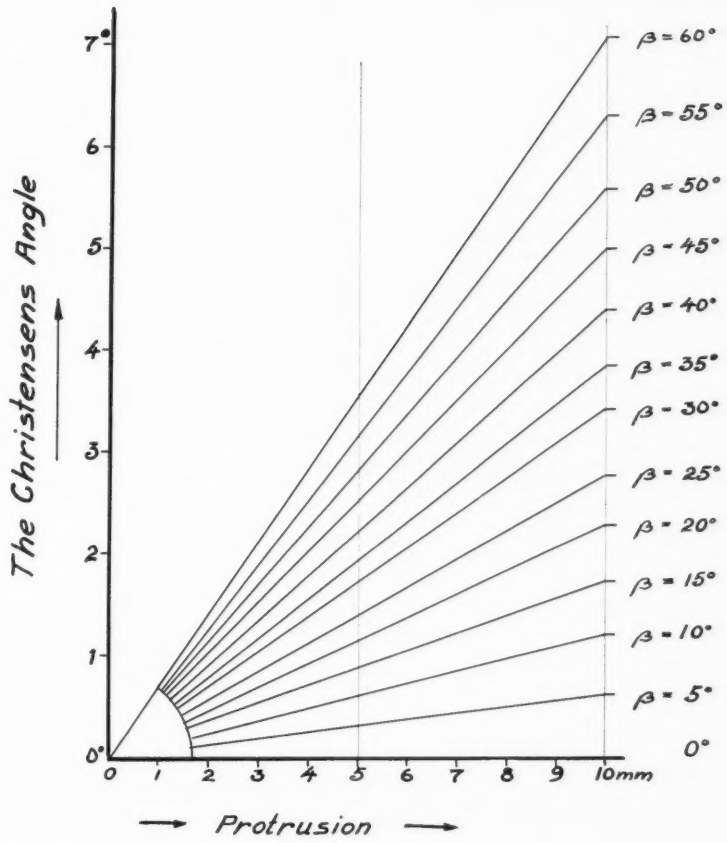

Fig. 8.—Graphic reproduction of Table III. The graph shows the size of the Christensen angle by various lengths of protrusion and different sizes of the condylar guide inclination (β). A protrusion of 5 mm. is entered on the abscissa, and a perpendicular is erected from this point. Having found the condylar guide inclination (β) equal to 50 degrees, the intersection point of the perpendicular and the line marking $\beta = 50$ degrees is entered on the ordinate (left). By this example, with 5 mm. of protrusion and a 50-degree condylar guide inclination, a Christensen angle of about 2.8 degrees is indicated on the ordinate (left side).

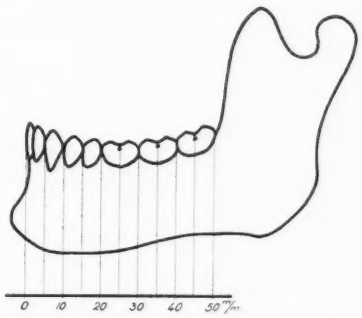

Fig. 9.—The occlusal surface. The projection is in the median plane.

IV, it is possible to calculate the cusp angle for each and all cusps by varying condylar guide inclinations (Table IV).

The cusp angle (ϵ) for third molar (M_3) can, from Table IV, be expressed for approximate values by means of Formula V:

$$\epsilon\, M_3 = \frac{\beta}{2}$$

That is, the cusp angle at the distobuccal cusp of the third molar can be taken as approximately equal to half the condylar path angle, if the incisal path angle and the occlusion curve are ignored.

In Table V the relationship between the cusp angle (ϵ) and the condylar guide inclination (β) is expressed by the following simple ratio (approximate values):

$$\epsilon\, M_3 = 5/10\,\beta$$
$$\epsilon\, M_2 = 4/10\,\beta$$
$$\epsilon\, M_1 = 3/10\,\beta$$
$$\epsilon\, P_1\text{-}P_2 = 2/10\,\beta$$
$$C = 1/10\,\beta$$

This relationship is shown graphically in Fig. 11.

TABLE IV. THE SAGITTAL ANGULATION OF THE DISTOBUCCAL CUSPS OF THE MANDIBULAR TEETH

TOOTH / β	10°	20°	30°	40°	50°	60°
Third molar (M_3)	5.68°	10.76°	15.39°	20.04°	24.89°	30.33°
Second molar (M_2)	4.49°	8.48°	12.25°	16.11°	20.13°	24.79°
First molar (M_1)	3.29°	6.24°	9.04°	11.92°	15.05°	18.70°
Second premolar (P_2)	2.10°	3.98°	5.79°	7.65°	9.70°	12.15°
Cuspid (C)	0.9°	1.70°	2.49°	3.10°	4.19°	5.28°

β = condylar guide inclination.

TABLE V. THE RELATION BETWEEN THE CONDYLAR GUIDE INCLINATION (β) AND THE CUSP ANGLE (ϵ) OF THE VARIOUS MANDIBULAR BUCCAL CUSPS (APPROXIMATE VALUES)

ϵ / β	10°	20°	30°	40°	50°	60°
M_3	5°	10°	15°	20°	25°	30°
M_2	4°	8°	12°	16°	20°	24°
M_1	3°	6°	9°	12°	15°	18°
P_1 and P_2	2°	4°	6°	8°	10°	12°
C	1°	2°	3°	4°	5°	6°

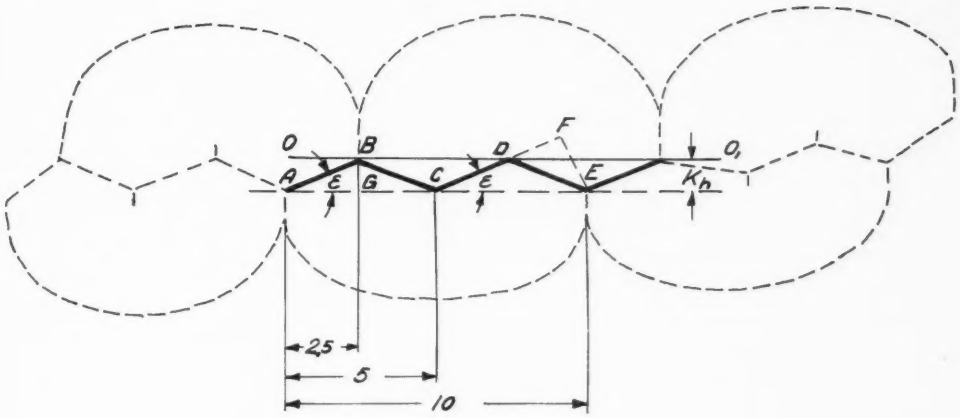

Fig. 10.—Schematic drawing of the height of the cusps *(Kh)*, the cusp angle (ϵ), and the sagittal size of the cusp (*AC* and *CE*).

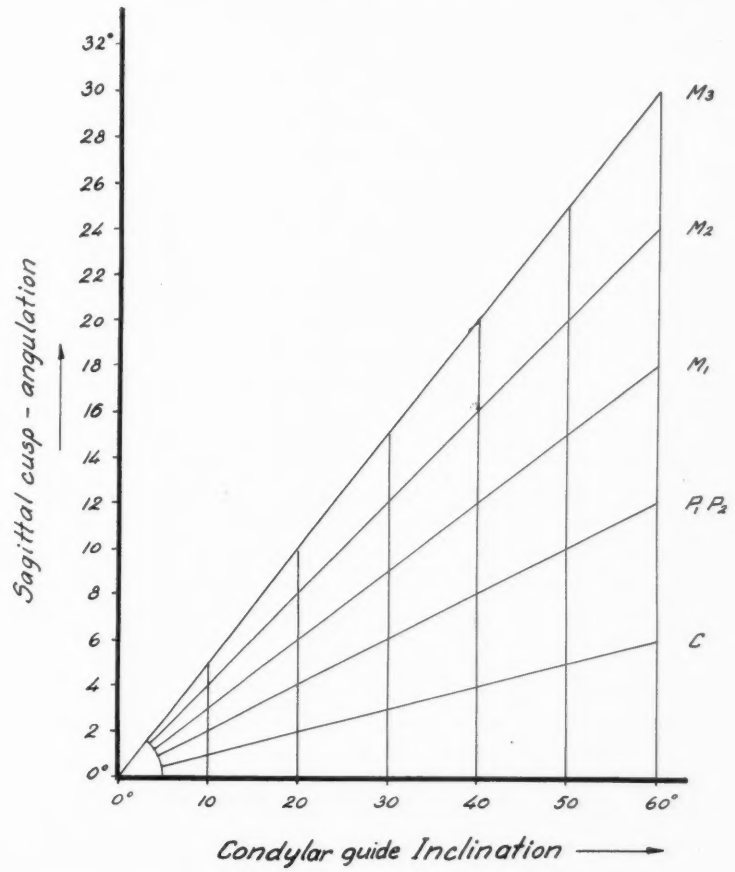

Fig. 11.—Graphic reproduction of Table V. The graph shows the cusp angulation necessary (ordinate left) for the third molar *(M_3)*, the second molar *(M_2)*, the first molar *(M_1)*, the premolars *(P_1* and *P_2)* and the cuspid *(C)* to be in harmony with the different degrees of the condylar guide inclinations.

When comparing the approximate values in Table V, with the exact values found in Table IV, the difference between the respective angles is found to be less than 1 degree, that is, a difference in cusp height of less than 0.1 mm.

The cusp angle is calculated by assuming a protrusion equalling 2.5 mm. In order to obtain balanced occlusion for protrusive movements of greater length, the compensating curve of occlusion can be used, or sliding contact can be maintained by increasing the length of the protrusion facets of the cusps (BE, Fig. 10). Cusps with common cusp angulation of the protrusion facets, therefore, can be of varying heights. In this case, the retrusion facet[11] (FE, Fig. 10) will be steeper as the cusp height increases. It is, therefore, more correct to say *cusp angle* rather than *cusp height.*

When setting up *cuspless* posterior teeth, with the intention of attaining a smooth-running balanced occlusion, it is necessary to regard the entire occlusal surface of the cuspless tooth as one single protrusion facet. The inclination of this surface to the plane of occlusion is equivalent to the cusp angle. The inclination between the occlusal surface and the plane of occlusion have to be angulated in accordance with Table V. In the instance mentioned, the occlusal surfaces appear as a curve of occlusion which coincides with the inclination of the condylar guidance.

SUMMARY AND CONCLUSION

In order to attain complete antagonistic contact along the entire length of mandibular protrusion facets during a sagittal gliding (protrusive) movement of the jaw, coincidentally with a minimum of horizontal stresses, the sagittal cusp angle must be in relationship to the inclination of the condylar guidance. The calculation of the cusp angulation is based on the Christensen phenomenon.

Under certain conditions which are specifically outlined, the Christensen angle can be calculated from the inclination of the condylar guidance, the length of protrusion, Bonwill's triangle, and Balkwill's angle. Christensen's angle for a protrusion of 5 mm. increases by approximately 0.5 to 0.6 degree for every 10-degree increase in the angle of the condylar guidance. The Christensen angle increases proportionally with the length of protrusion. Therefore, it is possible to construct a table in which the Christensen angle can be read when the length of protrusion and the inclination of the condylar guidance are known.

By means of the Christensen distance, it is possible to calculate the cusp height and the sagittal cusp angulation for the different buccal cusps.

To attain balanced occlusion by using cuspless posterior teeth, it is necessary to regard the entire occlusal surface of the cuspless tooth as one single protrusion facet and set up the teeth accordingly.

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COMPLETE DENTURES SUPPORTED BY NATURAL TEETH

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THE LARGE NUMBER OF young people, particularly those between the ages of 18 and 30 who become edentulous, should be of grave concern to our profession, especially to prosthodontists. One out of every five Americans has lost all his teeth by the time he reaches the age of 40, according to *Consumer's Report.* At the age of 50, the ratio is two out of five, and at the age of 70, three out of four.

Through medical advancements, life expectancy at birth has been increased to the age of 68. In 1900, it was less than 50 years. At the time of the American Revolution it was 36 years. The problem of wearing dentures for this increased period becomes very significant, when viewed in the light that eating becomes more and more of a pleasantry as one approaches the sunset days of life. Eating, to elderly people, is the one recreation from which even the bedridden patient can derive great pleasure if he has the "wear-with-all" with which to participate.

The architecture of the maxillae and mandible was designed to house the roots of teeth, not to act as support for artificial dentures. It is inevitable that resorption occurs when teeth are removed from that architecture. The rate of resorption depends upon three things; the character of the bone, the health of the individual, and the amount of trauma to which the structures are subjected.

The need for help of individuals who are victims of resorption has been brought to the attention of the profession by a group of dentists striving to do something about this problem. Whether or not one agrees with the principle of implant dentures is a matter of one's individual knowledge and understanding of the biologic sciences in addition to personal opinion. All must agree, however, that stimulation of thought concerning resorption has been brought about by the group which advocates this procedure. It is hoped that more dentists will engage themselves in clinical investigation which will help solve this tremendous problem.

The only satisfactory method of combating resorption, and the only sure means of preventing it, is by thoroughly educating patients to seek treatment of their teeth and oral structures while these structures are still intact.

Until dental research and science discovers a means of preventing the loss of teeth, the dominant mission of prosthodontics is to conserve that which the patient has. Unlike other parts of the body, teeth and supporting structures are not regenerative. There is no support for occlusion as adequate as the roots of

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The opinions or assertions contained herein are those of the author and are not to be construed as official or as reflecting the views of the Army Department or the United States Army at large.

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natural teeth, therefore, it behooves us, as physicians, surgeons, and physiologists of the oral cavity, to preserve to the very best of our ability, that which has not been lost. The removal of teeth because they interfere with the construction of a dental prosthesis does not promote dentistry as a member of the healing arts. The healing arts are intended to aid and add to the life of living tissue, not to destroy it. Do anything to the teeth except extract them; of course, in instances of pathology there is no alternative.

SUPPORT OF RESTORATIONS

It does not need to be debated that roots of teeth offer a better medium of support for an artificial replacement than the mucoperiosteum. The fixed partial denture, when properly formulated, is dentistry's best means of replacing missing teeth. It is the author's purpose to discuss a procedure which projects into the complete denture field the fixed partial denture principle of replacing missing teeth.

Every dentist can recall instances where teeth have been extracted for the want of such a method. Many teeth sentenced to extraction could have been utilized to support and stabilize a denture prosthesis for a long period of time. Teeth are biologic by nature; teeth which support a complete denture prosthesis can therefore be referred to as "biologic stabilizers."

In nearly every instance of a full mouth extraction, two, three, or four teeth could be salvaged and restored to a degree of health and to act as supports for the complete dentures. Even if a short life expectancy of the teeth is anticipated and their value in preventing resorption is not considered, the assistance they would lend in helping patients become accustomed and habituated to dentures is worth the effort. This statement, of course, is not meant to infer that pathologic teeth should be retained and used as supports.

Ten years of clinical investigation into the use of isolated teeth as supporting media for complete dentures has shown quite surprisingly that weak teeth used as support for denture prostheses not only remained in position but, in a number of instances, have regained a healthier status. Many teeth which had a poor prognosis outlived their estimated life expectancy for long periods of time.

We are certain that in all cases the teeth which support the denture are subject to greater stresses than that for which the root structure and supporting tissues are intended and the odds against their remaining healthy is great; but in spite of the additional load, many are successfully serving as supports for denture prostheses.

During the past 6 years, 46 dentures have been inserted, under which isolated teeth were used as the principle means of support; 34 have been immediate insertions.

Evidence of lessened resorption of the ridge tissues in these 46 cases is proved by the fact that the dentures have required no refitting. For immediate denture patients, the denture-bearing area opposing the newly surgerized tissues were corrected to keep pace with the healing processes. Most of these immediate dentures have been placed in mouths of young individuals (less than 30 years of age). It is hoped that the later days of their lives will be more enjoyable, because teeth rather than the mucoperiosteum, are now supporting their dentures.

TECHNIQUE

The procedure is not difficult. Generally speaking, the teeth which are to act as supports for the prosthesis are prepared as if full crown coverage was intended; a shoulder type of preparation, although not essential, is desired (Fig. 1). The shoulder provides space for a porcelain or a plastic labial insert in the thimble portion of the prosthesis and makes an oversized lingual surface unnecessary. There is one important difference in preparation—the normally flattened occlusal portion of the abutment teeth should be rounded or parabolic in form.

Such a preparation permits the stresses of occlusion to be directed along the long axes of the abutment teeth and allows for some movement of the denture. The abutment tooth plays no part in the retention of the denture; it acts as a stabilizer. Frictional retention is not wanted; using the teeth for more than support of the denture will shorten their life. Retention of the denture is by interfacial adhesion between the tissue side of the denture and the mucosa.

Thin wall (26 gauge) castings (copings) are made to cover the prepared abutment teeth (Fig. 2) and cemented to place. All exposed tooth surfaces should be covered in an effort to prevent future carious lesions from developing.

A nonpressure type of impression and maxillomandibular relationship records are made. The casts are poured and related to the articulator by the usual method.

Wax veneer crowns are formed over the cast of the jacketed abutment teeth, the occlusion is developed in harmony with the opposing teeth. The wax pattern should include a 4 or 5 mm. collar on the mesial, lingual, and distal surfaces at its cervical portion. When cast, this collar provides fixation for the veneer crown to the acrylic resin base. The wax pattern should make provision for a tooth-colored insert on its labial surface. The veneer crowns, when completed, are called "thimbles" (Fig. 3).

The patterns of the thimbles are invested, cast in hard gold, and the labial or buccal tooth-colored insert placed. The completed thimbles are placed on the master cast, the missing teeth are positioned for occlusion, and the denture is waxed for try-in.

The path of insertion and esthetics determines the extent of the labial and buccal flange of the denture which covers the labial and buccal gingival portion of the abutment tooth. Whether the flange is complete, partially extended, or absent (Fig. 4), is left to the discretion of the dentist for each individual patient. The length and contour of the flange of this area is determined by the contour of the labial tissue as it relates to inserting the denture. Undercut areas should be avoided. At the time the wax denture is tried in, an indication of the extent of the flange area should be made on the master cast.

After approval of the try-in, the thimbles are removed from the wax denture and cemented to the master cast. It is important that the thimbles be fixed to the master cast during fabrication procedures to prevent seepage of resin into the inside of the thimbles. A malrelation of the thimbles to the abutment teeth and the finished denture will result if this step is neglected.

After the thimbles are cemented, the wax denture is placed on the master cast and the wax-up is completed. The flange area approximating the abutment tooth is terminated at the line indicated on the cast.

The denture is processed in the usual manner.

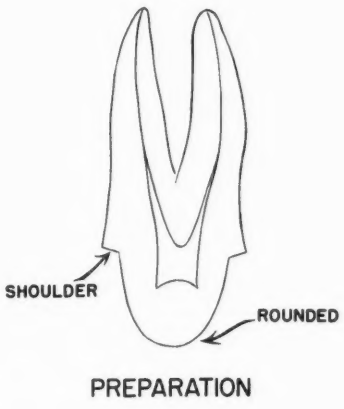

Fig. 1.

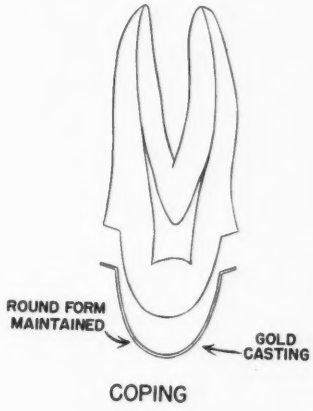

Fig. 2.

Fig. 1.—Schematic drawing of the preparation showing the rounded coronal portion and the cervical shoulder.

Fig. 2.—The casting should be thin as possible—26 gauge is the desired thickness. The rounded form of the coronal portion of the preparation should be maintained. The coping should be cast in hard gold.

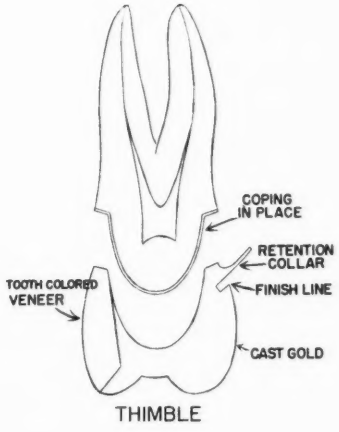

Fig. 3.

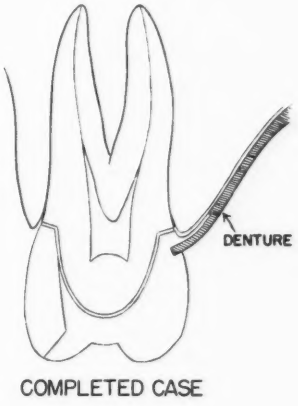

Fig. 4.

Fig. 3.—Copings are cemented to place, and final impressions are made over the copings. Utilizing maxillomandibular records, the master casts are articulated in the usual manner. A wax pattern in the form of a veneer crown is constructed over each abutment tooth on the master cast, with space provided on the labial surface for a plastic or porcelain insert. The retention collar of the veneer insert is developed by using 26- or 28-gauge wax, 4 or 5 mm. in width, and attached to the cervical portion of the thimble. A finishing margin for the denture resin should be carved in the lingual surface of the wax pattern.

Fig. 4.—A cross-section illustration showing how the cast thimble, with its tooth-colored insert, is attached to the denture. In this instance there is no labial flange.

SUMMARY

In many instances of full mouth extraction, some natural teeth and their supporting structures can be restored to health and serve a useful function for long periods of time. Even if the teeth show evidence of a short life they can serve purposefully in habilitating new denture wearers to their new means of mastication.

The use of teeth instead of, or in addition to (depending upon the number of teeth remaining and their position in the arch), the mucoperiosteum precludes the patient from "chewing on his gums" at least for a time. It permits the stresses of occlusion to be borne partially by the teeth, thus reducing the abuse which the alveolar process and the mucoperiosteum undergo when dentures are worn. By reducing the trauma to the mucosal tissues, it is reasonable to expect that resorption of the alveolar process will be lessened. The biologic maintenance of a neuromuscular mechanism, the temporomandibular articulation and the supporting structures of a denture can be accomplished better by teeth than by the mucoperiosteum.

Special emphasis should always be placed on the preservation of tissues which support artificial teeth. The use of teeth as support for dentures is aimed at reducing the load on the osseous portions of the denture-bearing area and minimizes the process of resorption.

Doing anything to lessen atrophy of the alveolar process will help preserve the denture-bearing area for the sunset days of the life of the patient, an anticipated life which is 20 years longer today than it was in 1900, and preserve it for a time when the patient needs it most. Such a procedure as has been described helps direct our efforts in preserving the supporting structures, both in health and in function.

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CERTAIN OBSERVATIONS ON A COMPLETE DENTURE PATIENT

Part II. Electromyographic Observations

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A DESCRIPTION OF THE principle and detail of the apparatus used in this myographic study appears elsewhere.[2] Surface electrodes were attached bilaterally over the gonial angles of the mandible in the center of the area of insertion of the masseter muscles. Similar electrodes were attached over the middle fibers of the temporal muscles at the superior limits of its origin. Reference electrodes were fixed to each ear lobe.

Electromyographic recordings were obtained at weekly intervals, thus giving three sets of records for each denture. Tracings were obtained under the following conditions: (1) at rest, (2) during volitional mandibular movements which did not involve tooth contacts, (3) during forced closure in the intercuspal position, and (4) during chewing of Tootsie Roll and carding wax.

The gain in amplification of the electromotive force was set in the rest condition studies to produce a 1 mm. vertical pen deflection for 6 microvolts. In the remaining conditions recorded, less amplification was used and a pen displacement of 1 mm. per 20 microvolts.

In analyzing the electromyographic records, differences in amplitude and timing were seemingly of prime importance, and reference is made to these two features when comparing muscular activity with the various dentures. No reference is made to changes in frequency, although it is generally agreed that changes in this characteristic vary with the speed and degree of activation of the various motor units. However, when surface electrodes are used, this feature is completely masked by the large volume of muscle from which changes in electrical potential are registered.

REST CONDITION

The resting electrical activity was recorded first without the dentures in place, and minimal activity was noted. With the placement of the muscular denture (M), this minimal electrical activity did not change for the specific amplification used

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Part III: Consideration of the Results from a Neuromuscular Viewpoint will follow in a subsequent issue of the JOURNAL OF PROSTHETIC DENTISTRY.

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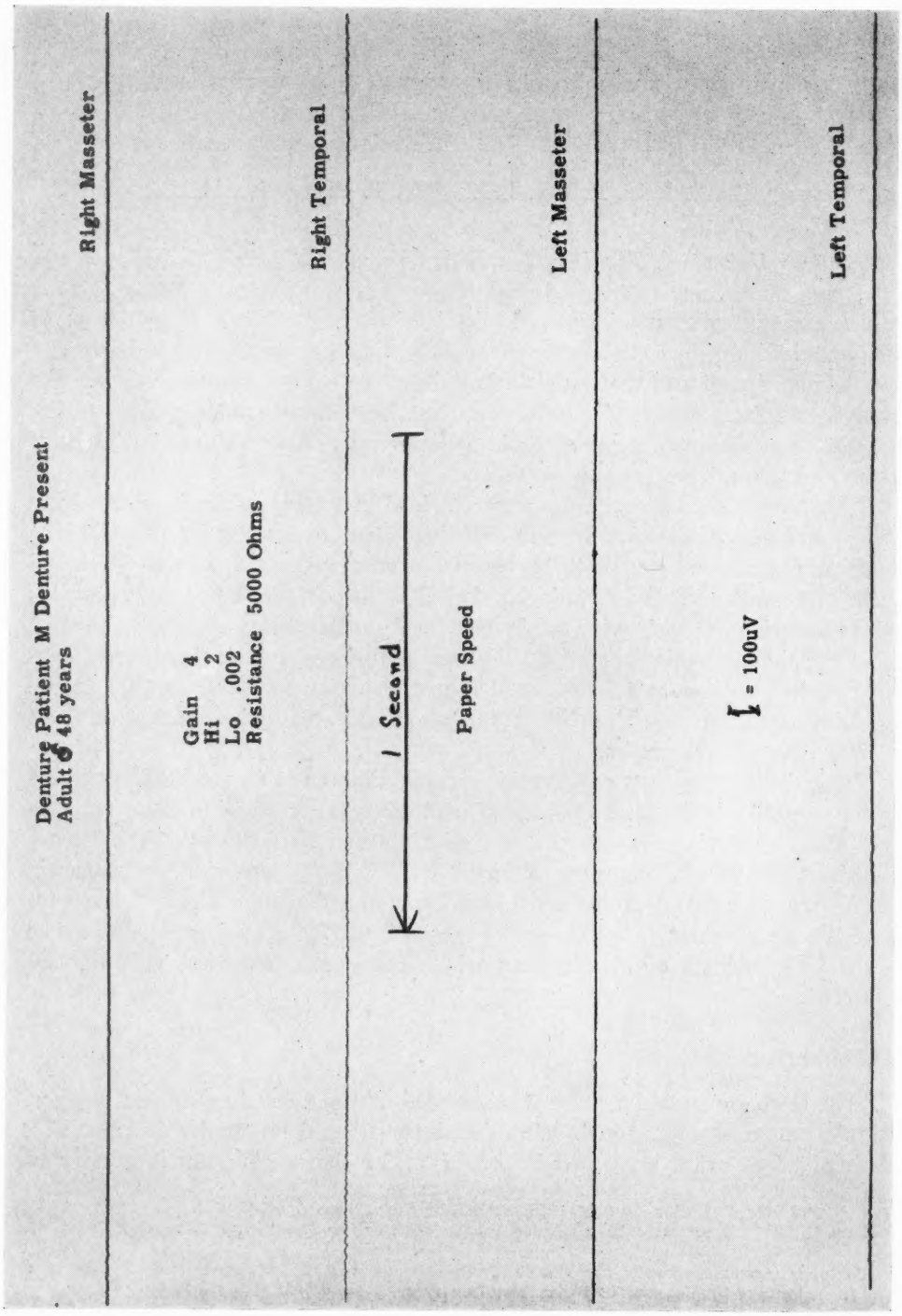

Fig. 1.—Electromyogram at rest position with the muscular denture (M) in place.

(Fig. 1). However, when the second open denture (O_2) was inserted, a great deal of electrical discharge was noted in the temporal muscles and a small amount in the masseters (Fig. 2). It is probable that this is a stretch-reflex-type firing of the various motor units initiated by the increased vertical dimensions. Similar discharges, not of such great magnitude, however, have been noted in rest-position studies immediately after plaster has been introduced about the mucosa and teeth to record mandibular positions.[2] In these latter instances, the reflex firing of motor units is due to a stimulation of mucosal tactile endings and not to a stretch of muscle-tendon organs, as would presumably be the cause in the former case. It is conceivable that the afferent signals of this stretch reflex firing could arise from the temporomandibular joints or oral mucosa as well as the muscles themselves. Possibly all three contribute to some degree.

Fig. 1.—Electromyogram at rest position with the muscular denture (M) in place.

NONOCCLUDING JAW MOVEMENTS

As might be expected, recordings from the masseter and temporal muscles during mandibular movements, not involving teeth contact, such as wide opening and protrusion, showed no differences with different lower dentures in position. Such movements are primarily volitional and are always smoothly enacted in the healthy individual.

FORCED CLOSURE

Forced volitional contraction of the muscles with the upper and lower cusps of the dentures maximally interdigitated was used to determine if variations in muscle exertion existed in the different mandibular positions selected. Results are tabulated in Table I giving a four point assessment of the amplitude noted on the myograph for each denture at the three times specified. (The electromyographs of the two most different patterns of power are shown in Fig. 3.)

TABLE I

DENTURE	MASSETER			TEMPORAL		
	FIRST PLACED	AFTER 1 WEEK	AFTER 2 WEEKS	FIRST PLACED	AFTER 1 WEEK	AFTER 2 WEEKS
Muscular (M)	++++	++++	++++	+++	++	++
Retruded (R)	+++	+++	++	+++	+	++
Artificially retruded (A.R.)	++	++	++	+	++	++
Protruded (P)	++	++	++	+	++	++
Open I (O_1)	++	++	++	+	+	+
Open II (O_2)	++	++	++	+	+	++

From the evidence of histologic appearances and electrical activity, it has been postulated that the temporalis is the initial mover or positioner of the mandible, whereas the masseter applies the power.[3] However, both muscles work in a complementary and supplementary fashion in each or both phases.

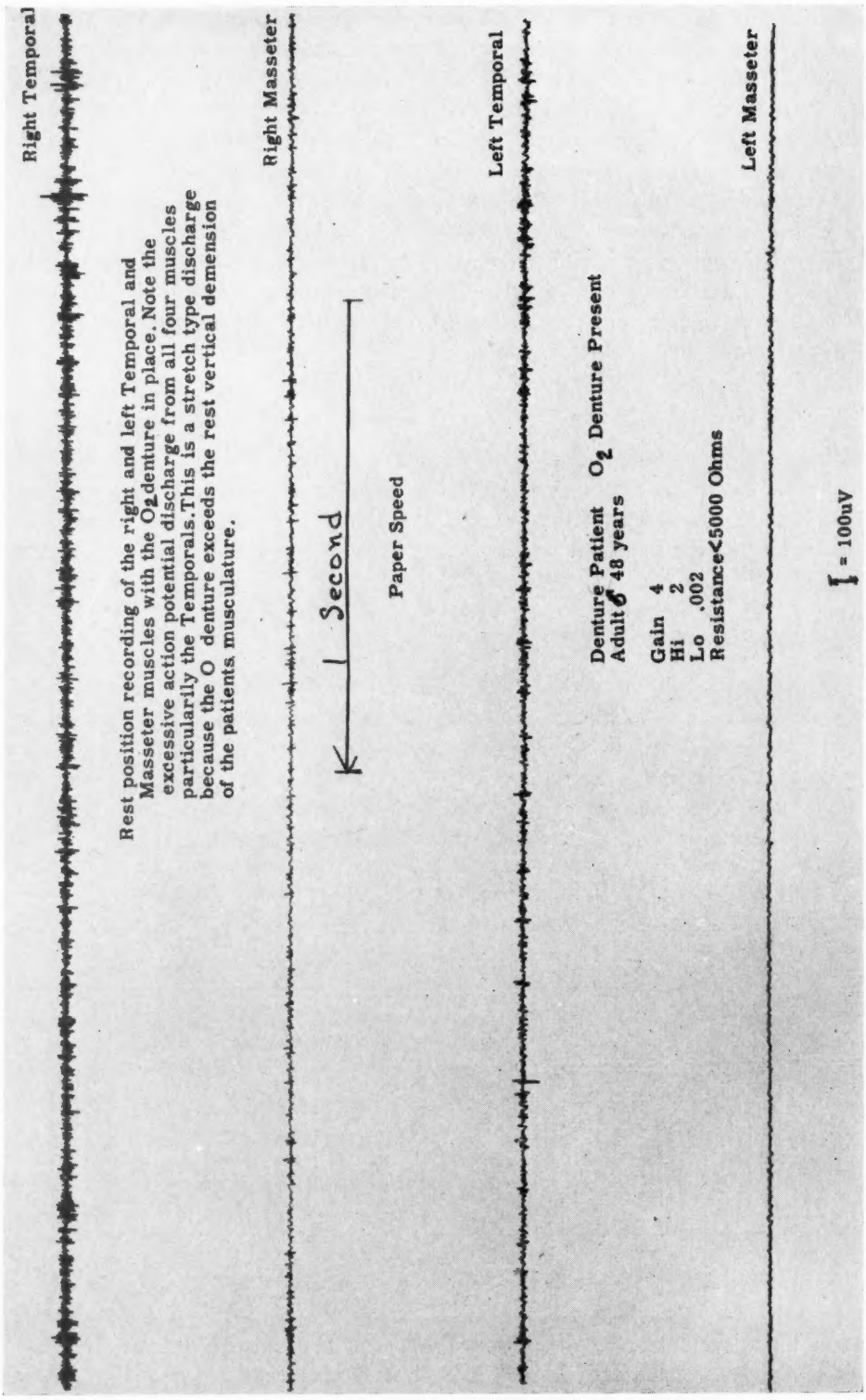
Right Temporal
Rest position recording of the right and left Temporal and Masseter muscles with the O2denture in place. Note the excessive action potential discharge from all four muscles particularily the Temporals. This is a stretch type discharge because the O denture exceeds the rest vertical demension of the patients musculature.
Right Masseter
1 Second
Paper Speed
Left Temporal
Denture Patient O2 Denture Present
Adult ♂ 48 years
Gain 4
Hi 2
Lo .002
Resistance<5000 Ohms
Left Masseter
= 100uV

Fig. 2.—Electromyogram made with the (O_2) denture (open 3 to 4 mm. beyond rest position) in place.

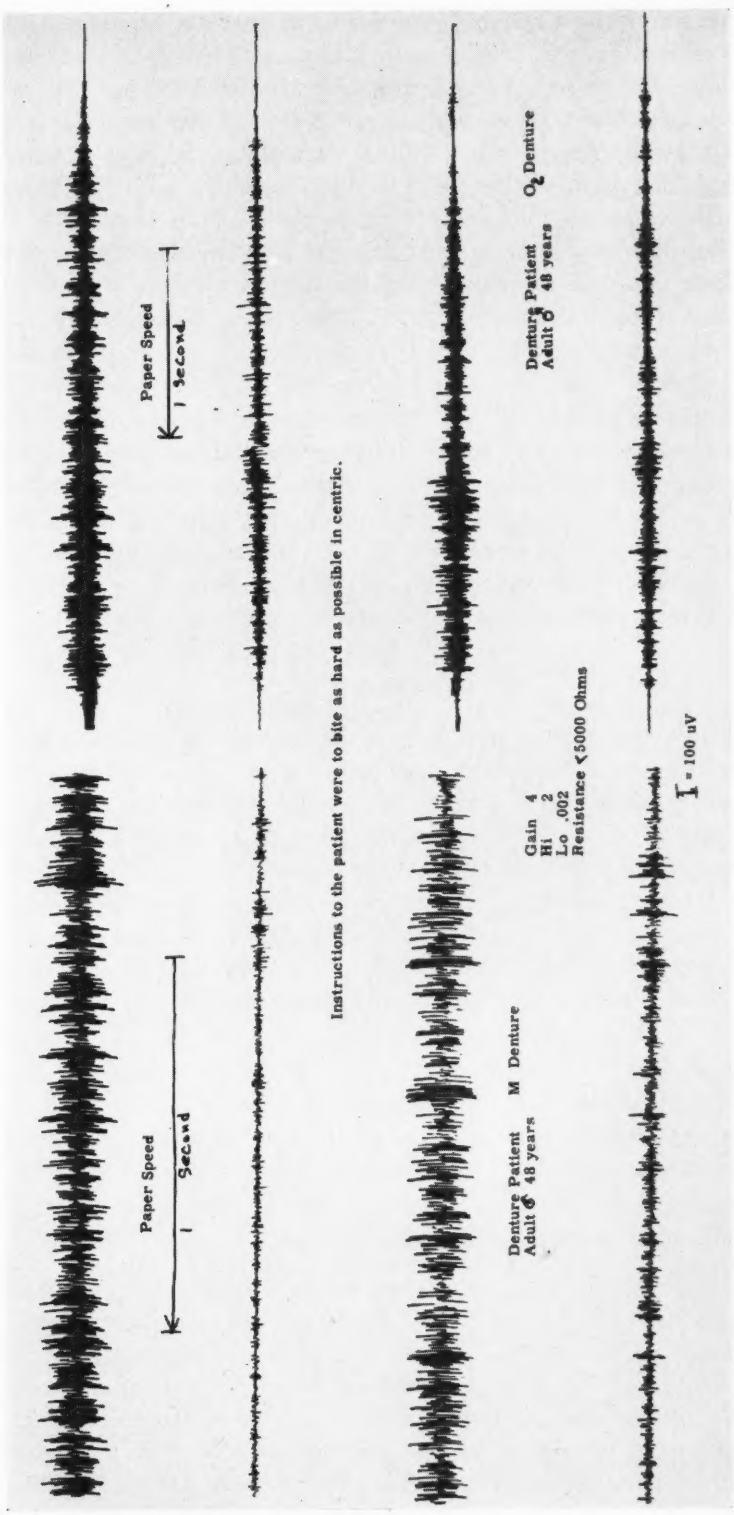

Fig. 3.—A comparison of electromyograms made in hard centric position closure with the muscular denture (M) and with the 3 to 4 mm. open denture (O_2).

Fig. 2.—Electromyogram made with the (O_2) denture (open 3 to 4 mm. beyond rest position) in place.

With this surmise in mind, it can be seen that maximal masseter activity and consequently maximal power acted only in the muscular position (median centric occlusal position). Either anterior or posterior mandibular displacement was accompanied by decreased masseteric discharge. A similar condition was noted with the open dentures, an increase of the occlusal vertical dimension being accompanied by a decrease in the recorded amplitude. In the case of the most widely open denture, a positive correlation may be noted between the subjective comment of the patient and the electromyographic finding: both indicated decreased power. This finding confirms the work of Boos,[4] who, by using a Bimeter, demonstrated that the biting force was reduced as the vertical dimension was increased. Comment must also be made on the stability of the masseter activity which was not altered from week to week.

On the other hand, temporal activity was seen to change from week to week in some cases. On the assumption that the temporalis is mainly the positioning muscle, increase in temporal activity can be attributed to increased "searching effort." This would account for the increased activity seen on first inserting the muscular denture (the first to be given to the patient) and its subsequent decrease after one week with the denture in place; that the temporal activity increased as the open dentures were worn is more difficult to explain.

CHEWING

Weekly electromyographic records were taken when the patient chewed Tootsie Roll and carding wax. The records obtained in each case were very similar except for more "interenvelope" activity with wax due, perhaps, to the fact that the wax bolus tended to adhere to the acrylic resin teeth. For this reason, the findings reported are those observed when Tootsie Roll was chewed. It should be noted for later comparison that, upon the application of load, this food tends to flow, deforming in shape, but maintaining its integrity as a mass without fracturing. It becomes softer and therefore more easily deformed as mastication progresses but never provokes a maximum of chewing pressure, as it is also soluble in saliva.

The patient was asked to chew the candy first on the preferred side, which was always the right side, and after a period to roll the bolus to the other side and continue mastication. Unless stated to the contrary, the observations made apply to chewing on the side of preference.

ELECTROMYOGRAPHIC STUDIES OF MASTICATION

Electromyographic studies of mastication have been made in subjects with normal and abnormal occlusal patterns.[5,6] In the light of experience gained in these, it has been found useful to analyze the records on the basis of envelope and interenvelope activity. The envelope is recorded during the closing phase of the masticatory cycle and the interenvelope phase during the opening stage. Since the first is the more important and more significant as far as the masseter and temporalis muscles are concerned, it is examined with regard to amplitude, dura-

tion, and chronologic incidence from one muscle to another. Comment, when significant, is made on the activity during the roll of the bolus from the right side of the mouth to the left. Observations are finally made of the changes noted in the records as the denture was worn.

The Muscular Denture.—Envelope amplitude and duration were greatest in the masseter muscle on the working side, and these were maximal when the right or preferred side was used for chewing. Peak amplitudes occurred simultaneously in all four muscles. Interenvelope and roll activity were very small. The envelope amplitudes of all four muscles were greatest on insertion of this denture. Activity during mastication decreased after one week and was unaltered during the second week. This suggests more efficient mastication after a period of wear. Timing, too, although always very good, improved.

In the respects described, the electromyographs obtained from the muscular denture resemble those obtained from subject with a normal natural dentition.

The Retruded Denture.—The electromyographic records of the retruded denture showed little difference from those of the muscular denture. It was, however, possible to note in all occluding exercises diminution in the amplitude of both the masseters and temporals, as well as a shorter envelope duration. This latter feature would seemingly indicate a briefer chewing stroke and a reduced masticatory pressure application.

The timing and synchrony of the working and balancing side musculature was well within a range of acceptable performance for a normal occlusion.

The apparent decrease in temporalis power in forced closure, after one week's wear, is difficult to interpret (Table I).

The Artificially Retruded Denture.—The envelope amplitudes in this case are similar to those found in the muscular denture, the right working side showing greatest activity. Envelope duration is shorter than in the muscular denture, possibly indicating a masticatory stroke more "chopping" in nature. As a unique feature, the longest envelope duration is seen in the working temporal muscle. It is noted that chronologic relationship between temporal and masseter activity is better on the preferred side of mastication.

In contradistinction to the muscular denture, amplitude duration and timing show less desirable features as the denture is worn. It is possible that the denture functioned well at a volitional level, but poorly at a reflex level.

The Protruded Denture.—With regard to the amplitude of the recorded wave motion, a marked reduction is noted in the case of the masseter whereas the temporal remains approximately the same as in the muscular denture. Again the greatest amplitude is noted when the right is the working side. The envelope duration is longer on the working side, a feature in common with the muscular denture. Here, however, the peak amplitude on the working side, whether left or right, is preceded by simultaneous peaks in the other three muscles. Better timing is noted in the first two masticatory cycles than in subsequent ones; it may be that the former are not dependent on an occlusion with maximal interdigitation of the cusps while the latter are. More interenvelope activity is noted than in the muscular denture, especially on the balancing side; this may be accounted for as an "after-firing" as a result of stretch.

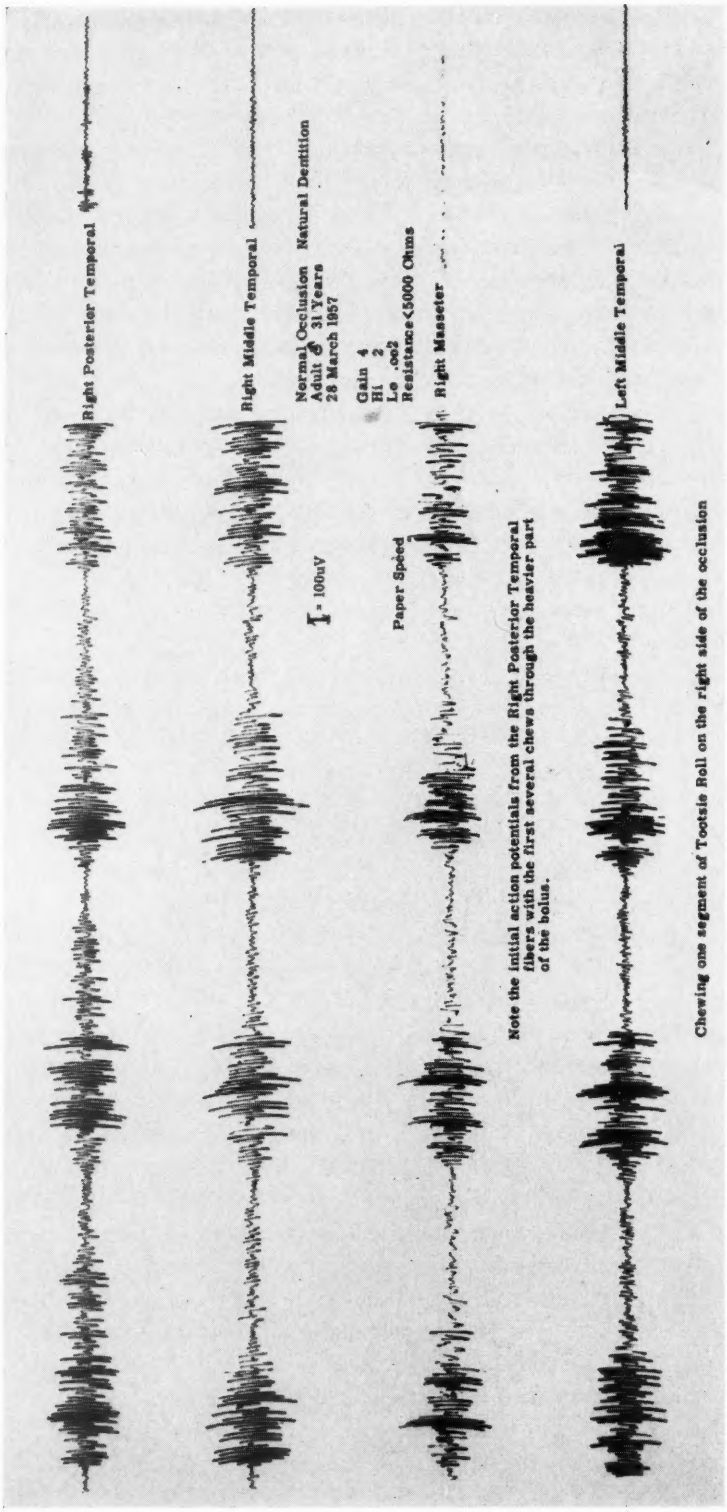
Right Posterior Temporal
Right Middle Temporal
Normal Occlusion Natural Dentition
Adult ♂ 31 Years
28 March 1957
Gain 4
Hi 2
Lo .oo2
Resistance<5000 Ohms
100uV
Paper Speed
Right Masseter
Left Middle Temporal
Note the initial action potentials from the Right Posterior Temporal fibers with the first several chews through the heavier part of the bolus.
Chewing one segment of Tootsie Roll on the right side of the occlusion

Fig. 4.—An electromyogram of chewing with a natural dentition.

After wearing this denture, severe pain developed; thus, observed changes in the electromyographic activity are more likely due to this factor than the learning of a new pattern. In fact, the chewing may be judged as purely volitional in character and aimed to reduce pain over the mylohyoid ridge area. The most important change is a further reduction in masseter amplitude, a condition calculated to reduce the pressure over the ridge at the expense of power application to the bolus. The masseter envelopes displayed two peaks suggesting a "testing" activity prior to an applied stroke, pain again being the cause. As might be expected in this volitional type of mastication, timing is improved and interenvelope activity is reduced.

The Open$_1$ Denture.—Here, for the first time, we noted that the amplitude of the temporal envelope is greater than that of the masseter, indicating, perhaps, difficulty in positioning the mandible. Peak amplitudes, as with forced occlusion, are less than in the muscular, retruded, and artificially retruded dentures. Envelope duration is increased over that found in the muscular denture. Timing is erratic and shows no constant picture with successive masticatory cycles. Interenvelope activity and roll activity are more marked than in the muscular denture. Whereas the first finding is readily accounted for in terms of after-firing, the latter may be a muscular sign of free-way space (interocclusal distance) obliteration and subsequent denture contact when the roll is performed nonvolitionally. After wearing the denture, the masseter of the left side showed greater maximal amplitude than that of the right side. It is probable that this effect resulted from a decrease in right side power in response to pain.

The Open$_2$ Denture.—In this situation, the maximal amplitude of the working masseter muscle was the least recorded in any of the dentures; it is very considerably less than with the muscular, retruded, artificially retruded, and Open$_1$ dentures. Temporal amplitude was, as in the Open$_1$ denture, greater than that shown by the masseters. The masseter amplitude on the working side was constantly less than on the balancing side. An explanation of this feature could only be speculative. It might, however, be likened to the condition seen in tertiary syphilis where there is proprioceptive degeneration. In these cases, there is a compensatory use of the tactile and sensory receptors in the guiding of muscle patterns. Here, it may be that the severe opening has brought about a derangement of the proprioceptive system and that touch on the balancing side of the denture was being used as a "feed-back" system to guide the muscular activity. Against this explanation, however, is the fact that the envelope timing was good. Short envelopes, too, were noted, which may be accounted for readily in terms of the shorter distance from the functionally open position to the occluded position. As would be anticipated, interenvelope activity was most marked in the roll activity.

It must be stressed that the results obtained are only indications of the masticatory pattern; they are certainly not valid measurements of masticatory efficiency. The patterns could, however, be compared with those shown in normal, natural dentitions when it was seen that the muscular denture approached most closely to them.

It became apparent as the experiment proceeded that the materials selected for chewing did not provide the severest test of mastication. Accordingly, at the

termination of the study when the oral condition was not painful, the patient was asked to incise and chew similarly sized pieces of raw carrot, the original comminution of which required considerable force. The subjective observations on this act have already been given. It also became apparent that on the working side it would be desirable to differentiate between anterior and posterior temporal action; accordingly, two surface electrodes were placed on this muscle; a third was located over the masseter. All of these electrodes were situated on the preferred working side, no information being secured from the balancing side. Electromyographic records were taken of a subject with a good, natural dentition as well as of the patient when using two of the lower dentures (M and A.R.).

In the subject with a normal, natural dentition (Angle: Class I), the first few masticatory strokes in breaking down the carrot bolus were initiated from a posterior and lateral position, the posterior movement of the mandible being accomplished by ipsilateral (in relation to bolus position) firing of the posterior temporal fibers (Fig. 4).

After the first four to seven strokes, the carrot square was broken, the need for power decreased, and the posterior mandibular shift ceased as did the initial firing of the ipsilateral posterior temporal firings.

A similar pattern was seen in our patient with the muscular (M) denture. The number of strokes required to break down the carrot bolus were greater than in the natural dentition subject.

In the artifically retruded (A.R.) denture, very little, if any, posterior shift was noted myographically or in the patient. There was less power available and more strokes were required to break down the bolus than in either the natural dentition case or the M denture.

The significance of this slight posterior shift on the so-called "working-side" and the initial firing from the ipsilateral posterior temporal fibers is still questionable until further research underway is completed. It may be of interest, however, on the grounds of teleology to speculate.

Maximal power from all muscles about a joint would seemingly occur when all of the muscles are acting. By slightly shifting the mandible to the lateral and posterior, the full force of muscle power about the joint is called in as the teeth close upward, medially and anteriorly, on that vector, through the bolus. This type of action was seen in the natural, normal dentition and in the M denture but not so in the R or A.R. dentures which were constructed on a terminal position. These latter positions thus prevented the mandible from closing on an anterior, upward, and medial vector through the bolus to centric occlusion. Further work with needle electrodes in the external pterygoid is being carried out now on this question.

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DENTURE IDENTIFICATION

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IDENTIFICATION OF BADLY MUTILATED bodies, or bodies burned beyond recognition, can usually be made if dentures are present. The dentures generally are not damaged because of the protection afforded them by the tissues of the head.

Dentures may be identified, or the correct mold and shade of teeth for the replacement of broken denture teeth may be selected by (1) the manufacturer's trade mark on the lingual surface of the teeth, e.g., a "Y" or a small crescent, or (2) by the name of the patient and the mold and shade of the teeth which may be processed in the acrylic resin of the denture base.

PROCEDURE

The denture is trial packed, and the flask is opened for the last time previous to final closing. The patient's name is typed on a strip of thin paper such as the kind that separates the sheets of baseplate wax. The mold number and shade of the teeth follow the patient's name on the piece of paper (Fig. 1), and it is cut so that it is just large enough to contain the desired information.

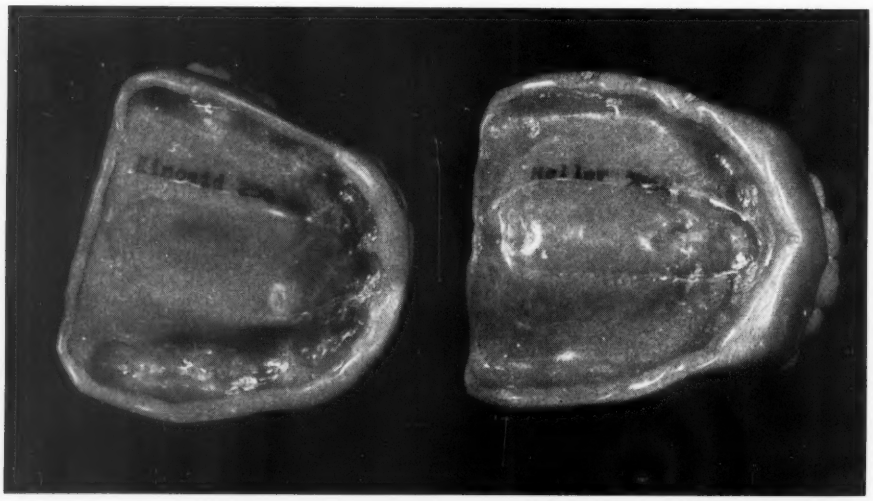

Fig. 1.—The patient's name, tooth mold, and tooth shade are processed in the denture base material.

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The acrylic resin on the palatal surface between the ridge and the center of the palate is moistened with monomer on a small brush. The strip of typed paper is laid on this surface and the paper is moistened also with monomer.

Clear or pink dry polymer is placed over the paper. The polymer is moistened with monomer from an eye dropper just before the final closure of the flask and processing. The typing will be more legible if clear acrylic resin is used.

SUMMARY

A method for including the patient's name, tooth mold, and tooth shade in the denture base material for identification purposes has been described. This simple procedure is not time-consuming, and it is effective.

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REMOVABLE PARTIAL DENTURES

THE CHALLENGE OF THE PARTIALLY EDENTULOUS MOUTH

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ONE OF THE GREAT challenges facing a dentist is affording his partially edentulous patients the benefits of long-range treatment planning for partial dentures. In rendering such a service, the dentist must accept a philosophy of treatment planning which gives maximum consideration to the total welfare of the patient. It is the purpose of this article to consider the benefits of such a program which can be carried out by most dentists for the majority of their partially edentulous patients.

OBJECTIVES OF LONG-RANGE TREATMENT PLANNING

There are three major objectives in this type of treatment planning: (1) the economic consideration of the treatment for the patient, (2) the avoidance of unnecessary duplication of effort, (3) the prolongation of the partially edentulous period for the patient.

When major emphasis is placed on the consideration of the patient, he will have the benefit of an individually thought-out treatment plan designed to cope with both his immediate and future needs. While an economic consideration may not be necessary for some patients, it certainly is of concern to the majority of them; therefore, the dentist should offer, wherever possible, an alternate plan as well as an ideal program, both of which will incorporate the fundamentals of good partial denture construction. Alternate plans may also be indicated because of age, health, and time factors. Such programs, designed to prolong the partially edentulous period for the patient, will do away with costly duplication of appliances and effort.

ACCOMPLISHMENT OF THESE OBJECTIVES

The accomplishment of these objectives places responsibilities on both the patient and the dentist. The dentist who would offer this service can no longer in his thinking view the partial denture as a mere "space filler" or temporary appliance. From the time he first sees his patient, he must begin in his diagnosis and prognosis to anticipate possible future problems. Foresighted planning, which takes into consideration subsequent losses of oral structures, can be accomplished only by a thorough diagnostic study of the patient to develop a comprehensive pro-

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gram. The presentation of this dental treatment program to the patient must be made in such a way that the patient is fully aware of its benefits and recognizes his responsibilities in follow-up treatment, in being available for such treatment, in oral hygiene home care, and in financial obligations. Convinced of the sincerity of the dentist in projecting a program which encompasses future needs, the patient is much more likely to accept these responsibilities in what must of necessity be a cooperative effort.

The education of a patient to the point where he is receptive to such a program is an added responsibility of the dentist, for frequently patients are inclined to neglect the replacement of a few missing teeth with partial dentures unless an esthetic factor is involved.

Possibly one of the greatest responsibilities placed upon the dentist in this type of treatment planning is the maintenance of the control of the planned treatment from the initial diagnosis throughout the entire partially edentulous period. He must recognize and use the advantages to be gained through the recent advances in periodontics and endodontics, fields of dentistry which can contribute greatly to successful partial denture treatment. He must select materials over which he has full control. Gold is the material of choice in partial denture construction, for its properties are known to the dentist, and it may be added to as future design alterations may require. The chrome-cobalt alloys have properties unknown to the dentist; he has no control over them in the initial partial denture construction, and future alterations of such appliances are very difficult, if not impossible.

The dentist, alone, by virtue of his training and experience, is equipped to offer partial denture service to his patients. He cannot do this by relegating his responsibilities to technical help, untrained in the basic sciences. When the dentist first examines his patient, the fundamental design is already indicated by the oral structures which are present. The dental destiny of that patient is then in the hands of the dentist who, through his training and experience, determines the means of preserving the remaining oral structures. This service cannot be rendered by anyone other than the dentist. Dental services of this nature almost necessitate a private patient-dentist relationship and will do much to offset current pressures toward socialized dental care.

CONSIDERATION OF FACTORS INFLUENCING PARTIAL DENTURE TREATMENT

An individual treatment plan for the patient must necessarily consider physical, psychologic, and economic factors peculiar to that patient which will influence his treatment program.

PHYSICAL FACTORS

A complete case study of the patient will encompass the anatomic, physiologic, and pathologic conditions which will affect the diagnosis and prognosis of treatment. Proper evaluation of the remaining hard and soft structures is essential. Because of the importance of the role the remaining teeth play in the support of a partial denture, they must be considered not only in relation to their number, but also from the standpoint of their location, condition, and type. A dental history

of the patient which will reveal the reason for previous loss of teeth can be a good diagnostic aid. There is a common tendency to use all teeth next to edentulous areas, as they are, for abutment purposes. Before this decision is reached, each tooth should be critically analyzed as to its vitality, caries, alveolar support, position, and as to the shape and form of its crown and root.

Bone is constantly changing. The patient's ability to maintain and repair this supporting structure for the partial denture is an important factor. It should be noted that the matter of density of bone is not always indicative of its response in supporting additional loads. Favorable response has been observed in both dense and less dense bone. Bone may have fewer trabeculae and be less dense; but if it has a good trabecular pattern, new building material can be filled in this pattern. The prognosis of the bone factor can be somewhat determined by its response in the past. However, the future picture may be altered by illness, accident, age, menopause, or dietary deficiencies. It may be advisable, in addition to studying the general health history of the patient, to consult with his physician and a periodontist.

A clinical study of the soft structures should be made. The tone, thickness, friability, and rigidity of the mucoperiosteum should be noted. An examination of the gingival sulci should be made with a periodontal instrument to determine their depth. Many signs of systemic disorders, such as diabetes or avitaminosis, manifest themselves in the soft structures and may indicate the need for proper therapy before partial denture treatment is begun. The size, contour, position, and muscular tone of the tongue may also affect the partial denture treatment.

The hard and soft structures of the mouth are fixed entities which must be accepted and evaluated. They necessarily limit the partial denture design and treatment plan. The temporomandibular joint, another fixed factor, is an important component of mandibular movement. Since the mandible moves on an axis that is located in or around the condyles of the temporomandibular joints, it is important to record and transfer this mandibular axis to an adjustable articulator. The articulator may then be opened and closed in such a way that the movement of the mounted casts approximates the physical movements of the jaws of the patient.

PSYCHOLOGIC FACTORS

Neuromuscular skills, adaptability and tolerance potentials, and speech performance must be evaluated from a psychophysiologic viewpoint to determine the prognosis of the treatment, for psychologic consideration of such factors may contraindicate partial denture treatment that would be acceptable purely from a physiologic consideration.

Partially edentulous patients tend to develop eccentric mandibular movements and habits. These may contribute to emotional upset and bruxism. The use of House's psychologic classification[1] of the patient is advisable, but because the mental attitude of the patient may change after treatment has been instituted, this classification should be subject to re-evaluation. Long-range partial denture treatment would be inadvisable for the hysterical or the indifferent patient whose attitude is not receptive to conditioning through education or preliminary treatment. A modified or alternate program may be required for these patients. The philosophic

patient usually is ideal for long-range treatment planning, while the exacting patient, motivated by the logic of the program, frequently becomes most cooperative in the mutual undertaking.

ECONOMIC FACTORS

A thorough diagnostic study of the patient is a service which requires the knowledge, experience, and time of the dentist. A fee should be charged for dental diagnosis just as it is for medical diagnosis. When the diagnostic study of the patient has been completed, the treatment plan can then be developed for presentation to the patient. With the presentation of this program, the first patient education begins. Therefore, all mediums contributory to patient understanding should be utilized. These may include study casts, roentgenograms, and designs, either drawn or waxed on study casts, illustrating initial and future provisions. The diagnostic consultation is essential to condition the *patient* to long-term thinking in relation to his dental treatment program. He must be instructed as to *why* various treatments and procedures will be employed in his program, and he must be made aware of the long-term value of such a program. In this way, he can properly evaluate the service being offered to him and decide whether the benefits of the program are worth the expenditure of his time and money.

In outlining the patient's responsibilities in this treatment, the dentist should stress the absolute need of thorough acceptance on the part of the patient for follow-up care and financial obligations. A discussion of fees should direct the patient's thinking toward a consideration of the initial cost, combined with the yearly maintenance cost, *divided by* the projected number of years the natural teeth may be retained, assuming no adverse factors alter the original prognosis. The patient should be advised that many conditions, such as illness, deficient diet, or accident, may modify the estimated treatment plan. Thus, the patient is conditioned to think, not in terms of the cost of the appliance per se, but rather in terms of the cost of the service throughout the years. What otherwise might be viewed by the patient as a high initial fee, actually represents low annual cost, since the program is designed to eliminate the expense of frequent new appliances. Method of payment should be clearly understood from the beginning, and if the patient is not familiar with the postpayment plans offered by various dental organizations, these should be explained to him. Once the economic factor has been given complete consideration, both the dentist and the patient are better prepared to devote their efforts to the successful accomplishment of the dental treatment program.

PRACTICAL LONG-RANGE PARTIAL DENTURE TREATMENT PLANNING*

The following treatment program will exemplify long-range prosthodontic treatment for various stages of degenerative dental diseases for a partially edentulous patient, progressing from Class III to Class II to Class I to Class IV of the Kennedy

*Applegate, Oliver C.: Postgraduate course in Partial Denture Prosthesis, May 20-31, 1957, W. K. Kellogg Foundation Institute, University of Michigan, and described in his book, Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1954, W. B. Saunders Co., pp. 120-165.

Classification.[2] The Kennedy Classification is a generally accepted one and will aid in identifying and clarifying the description of each partial denture design to be considered.

An ideal treatment program will be presented for each stage; however, since an ideal treatment cannot always be followed, alternate treatment plans will be indicated where necessary.

The following basic principles and details of design for partial dentures will be used: (1) broad distribution of stress to maximum areas, in order to minimize the stresses, (2) partial denture base coverage of maxillary tuberosities, (3) partial denture base coverage of retromolar pads, (4) utilization of cuspids as main anterior stabilizers with large deep rest seats,[3] and also as guides of occlusion, (5) external attachments and rests, (6) rigid cast gold frames used as broad major connectors.

Contrasting designs for maxillary and mandibular partial dentures are illustrated in Figs. 1,*A*, and *B*, and 2,*A* and *B*.

CLINICAL APPLICATION OF PRINCIPLES

The mere addition of teeth to an appliance without consideration of future stress loads is not the intent of this program. The control of total stress loads by keeping them to a minimum and within the limits of the tissue tolerance and health of the patient is the key to long-range partial denture planning. The application of these principles of planning for future stresses may be used in all four of the Kennedy Classifications.

A maxillary and mandibular Class III unilateral partially edentulous mouth will be used for the initial design of an ideal treatment program. The rationale and prognosis of this program will be considered for each of the subsequent classifications. Once the principles are understood, they may be applied to any classification modifications.

KENNEDY CLASSIFICATION III SITUATION

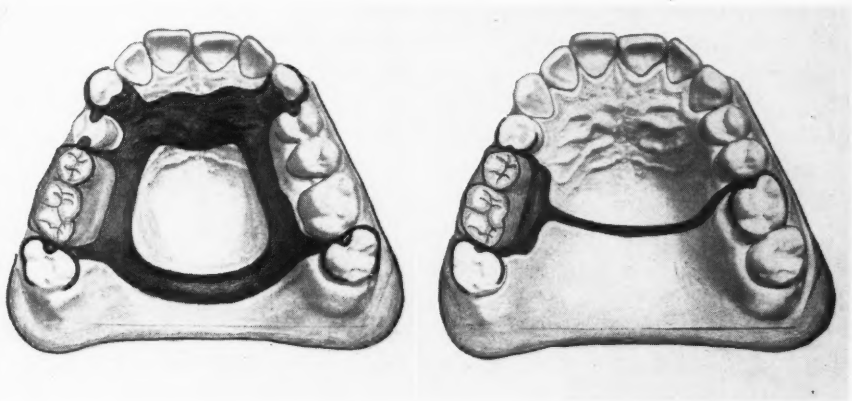
Figs. 1,*A* and 2,*A* indicate ideal designs where the posterior abutment teeth, which would ordinarily be used as the main posterior stabilizers, are considered weak from bone loss or from short, tapered roots. Although there are only a few teeth missing, there is evidence of bone loss on the opposite side of the arches which contraindicates unilateral removable or fixed partial dentures, since these would add to the stresses that are already present on the abutment teeth.

An alternate design may not include as complete palatal coverage or coverage of the retromolar pads and tuberosities. Such modifications are frequently used in good partial denture restorations.

Rationale.—By the application of a cross-arm splinting and bracing effect, which utilizes a bilateral, broad-coverage design, a tremendous amount of stability may be gained, and the stresses may be minimized. The design outlines a rigid frame that lends itself well to future alterations.

Prognosis.—If ideal restorative procedures have been used on the abutment teeth to provide for retention and stability of the partial denture and to insure the

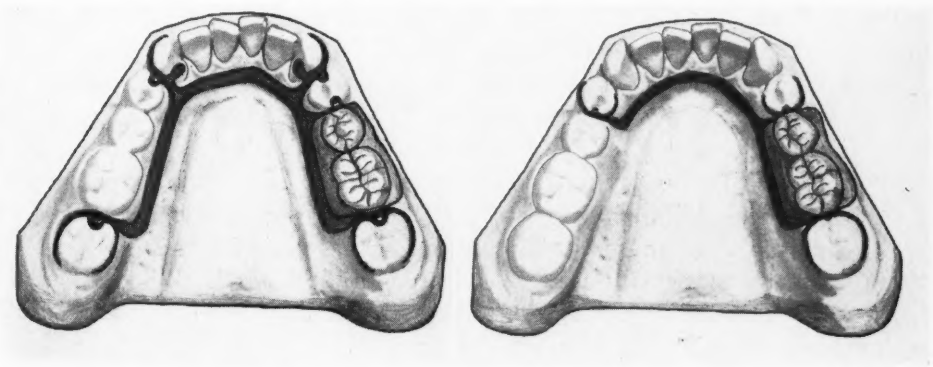
teeth against caries, the prognosis is favorable but dependent on factors of general health, patient care, and follow-up treatment. However, in an alternate program which may not include ideal restorations of abutment teeth and where the teeth may be modified by grinding to give a like effect, the prognosis cannot be as favorable as that in which full coverage has been employed. Ideally, in preliminary mouth preparation, restorative procedures should anticipate possibilities of nonabutment teeth becoming abutment teeth. The design of full coverage crowns for these teeth should incorporate rest seats and an undercut area which can be used for the retention of the partial denture. Thus, when subsequent tooth loss does occur, the



A. *B.*

Fig. 1.—*A*, A maxillary partial denture illustrating the application of the following principles and details of design: (1) broad distribution of stress to maximum areas in order to minimize the stresses; (2) utilization of cuspids as main anterior stabilizers with large deep rest seats and also as guides of occlusion; (3) external attachments and rests; and (4) rigid cast gold frames used as broad major connectors.

B, A maxillary partial denture illustrating the lack of fundamental principles of design.



A. *B.*

Fig. 2.—*A*, A mandibular partial denture illustrating the application of the following principles and details of design: (1) broad distribution of stress to maximum areas in order to minimize the stresses; (2) utilization of cuspids as main anterior stabilizers with large deep rest seats and also as guides of occlusion; (3) external attachments and rests; and (4) rigid cast gold frames used as broad major connectors.

B, A mandibular partial denture illustrating the lack of fundamental principles of design.

treatment plan will already have been established, and the modifications anticipated to permit an alteration relatively simple from the standpoints of cost, time, and effort.

Fig. 3 illustrates the alteration of the initial appliances (Figs. 1,*A* and 2,*A*) to provide for subsequent loss of the first molar tooth on the opposite side of the arch.

KENNEDY CLASSIFICATION II SITUATION

The loss of the most distal abutment tooth on one side changes the classification of the design from Class III to Class II (Fig. 4). A unilateral edentulous area located posterior to the remaining teeth changes the partial denture from a tooth-borne appliance to a tissue-borne appliance and subsequently presents different problems. The more posterior teeth lost, the more ineffective the partial denture. However, the loss of additional teeth in a Class II partial denture should not necessarily affect the direct or indirect retention.

The only component of the partial denture that must be altered is the denture base over the edentulous area. Although the distal outline of the edentulous area has been established, a functional impression should be developed; whereas with the tooth-borne initial partial denture, anatomic registration was necessary.

The two factors essential in Class II designing have been already established in our initial design, namely: (1) an indirect retainer anterior to the fulcrum line, and (2) a rigid major connector with its terminal end anchored as far as possible from the denture base.

Rationale.—A functional impression of the edentulous area by a corrective impression procedure permits the residual ridge to function under stress and to provide better support for the partial denture base.

In bilateral designing, the terminal attachment of the major connector on the most posterior tooth opposite the edentulous area counteracts the forces applied to the distal extension denture base. The indirect retainer becomes longer and more efficient when the posterior teeth are used for abutment purposes.

Prognosis.—Assuming that the mouth preparation previously considered in the Class III partial denture treatment has been maintained, the prognosis will continue to be favorable. The problems involved in supporting the distal extension denture base by an edentulous area are different and are of a continuous nature.

The prognosis will usually depend on how well all possible movements of the partial denture are controlled. This consideration was not a factor in the Class III design where the movements could be stopped. In the Class II, I, and IV partial dentures, the movements can never be stopped, but they may be controlled and minimized in the following manner:

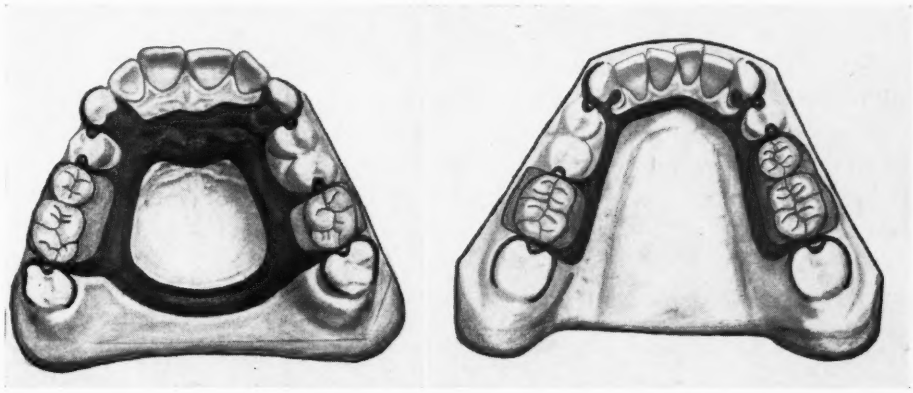
The rotational movement around the fulcrum line toward the residual ridge may be minimized by establishing accurate denture base form; however, there will be some resiliency which can be minimized by maximum coverage within the health and function of the foundation.

The rotational movement away from the residual ridge may be controlled by the efficiency of the indirect retainer. Ideally, the indirect retainer should be

rigid and placed perpendicularly to the fulcrum line, with its terminal end resting in a definite seat where the forces coming upon it will be directed to the long axis of the supporting teeth.

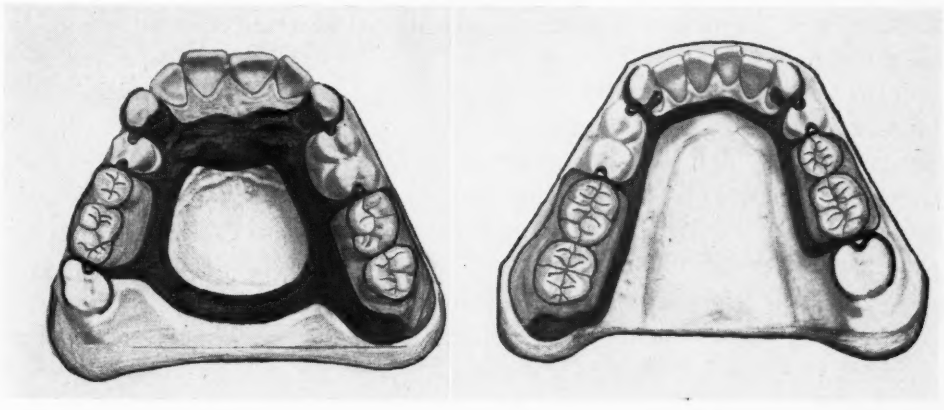
The lateral movements of the partial denture and the rotation of the denture base may be minimized by maximum coverage, rigidity, bilateral indirect retainers, reciprocal clasp arms, and fixed retention of the denture base to the major connector.

By keeping these movements to a minimum, the total stress on the supporting structure may be well below the estimated tolerance of the patient and consequently may have a stimulating effect. The structures supporting the partial denture may remain in a healthy condition for years without any apparent injury.



A. *B.*

Fig. 3.—The modification of the initial appliances (Figs. 1,*A* and 2,*A*) to provide for subsequent loss of the first molar tooth on the opposite side of the arch (Kennedy Classification III).



A. *B.*

Fig. 4.—The modification of the maxillary and mandibular partial dentures to provide for the loss of the most distal abutment tooth on one side (Kennedy Classification II).

KENNEDY CLASS I SITUATION

As was true in the change from a Class III to Class II situation (when subsequent posterior teeth are lost), the treatment plan is already established to modify the appliance for a Class I situation.

Fig. 5 illustrates the alteration of the partial denture from Class II to Class I because of the subsequent loss of the last remaining molar.

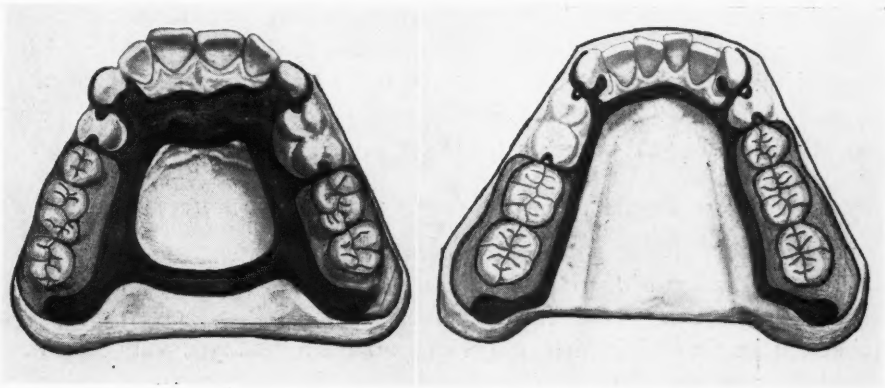
When Kennedy developed his classification, he took into consideration in this numbering the frequencies of the various types of partial denture fabrications; thus, a Class I partial denture is the type most frequently constructed, yet a Class I partial denture is the most ineffective and the *most* destructive. Contemplation of this very disturbing fact has prompted the writing of this article, for unfortunately, in many instances, insufficient thought has been given to partial denture treatment planning. To bypass a Class III or Class II partial denture because of a matter of expense or convenience is simply to bring the patient into a most difficult partial denture experience which will hasten the destruction of remaining structures. A consideration of the additional leverage control problems entering into a Class I partial denture will re-emphasize the desirability of forestalling this stage of partial denture treatment for the patient.

Since the distal extension bases are free and are supported by a resilient foundation, there are many movements brought about by these increased leverage forces. An evaluation of the partial denture and the supporting structures at this time may aid in controlling these destructive stresses.

MULTIPLE ABUTMENTS BY SPLINTING

Probably the most destructive stresses on the abutment teeth are those of torque and tilting. The use of multiple abutments by splinting will counteract these stresses. The anterior plus the premolar teeth are a common pattern of remaining teeth in a partially edentulous mouth. Frequently, the premolars cannot be considered as abutment teeth for a Class I partial denture, because of the size and shape of the single root, the clinical crown, and the condition of the supporting alveolar bone. This class of partial denture, using the premolars per se as abutment teeth, is, however, the most commonly constructed. This may well be a major contributing factor to the number of failures of the Class I partial denture. An effective way to overcome this problem is by splinting the weak teeth with cast gold restorations (Fig. 6). Effective splinting may be done when the tooth to be used as an abutment is standing alone, as shown in Fig. 7,*A*. The first premolar is missing, leaving the second premolar standing alone. The splinting of this weak tooth to the adjacent strong cuspid with a fixed partial denture will create a favorable abutment situation (Fig. 7,*B*).

Rationale.—The tooth, as observed in the roentgenograms, showed evidence of considerable loss of alveolar bone around its root, which was single, tapering, and conical in shape. Since it was slightly mobile and had withstood the stresses of stabilizing the partial denture for many years, it was thought best to immobilize it by splinting to reduce stresses. Thus, the splinting of a single-rooted, weak tooth would produce an abutment support comparable to that of a multirooted tooth. This union would insure stability of the tooth against further torque and tilting stresses. Splinting may also be advisable on an immobile, short-rooted tooth to prevent stress.



A. *B.*

Fig. 5.—The modification of the maxillary and mandibular partial dentures to provide for the subsequent loss of the last remaining molar (Kennedy Classification I).

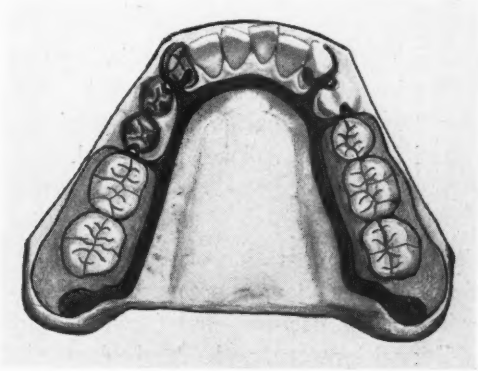
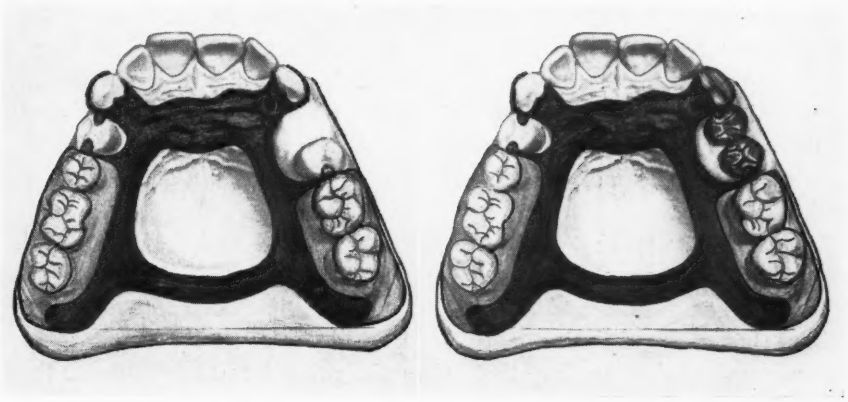


Fig. 6.—A mandibular partial denture supported by weak teeth which have been splinted.



A. *B.*

Fig. 7.—*A*, A maxillary partial denture with the maxillary left first premolar missing, leaving the second premolar standing alone and creating an unfavorable abutment situation. *B*, The splinting of the weak tooth to the adjacent strong cuspid with a fixed partial denture creates a favorable abutment situation.

DESIGN OF ABUTMENT RESTORATIONS

The design of full coverage abutment restorations should be considered in the carving of the wax patterns, using a surveyor to create desirable undercuts for the direct retention. The guide planes and clasps of the partial denture on the abutments should be gold-borne on the insertion and removal of the denture.

ALTERATION OF THE MAXILLARY AND MANDIBULAR PARTIAL DENTURE DESIGNS WITH THE PREMOLARS SPLINTED AND SERVING AS ABUTMENTS

Direct Retainers of the Partial Denture.—The cast gold direct retainers have been used in the cast partial denture. Since the alteration, however, there is a definite need for the combination type of clasp. An effective type will be the flexible wrought clasp as the direct retainer opposing a rigid cast reciprocal clasp arm.

Rationale.—The wrought wire retentive clasps are an essential aid in retaining the partial denture after the alterations have been made. It is particularly indicated in the Class I partial denture where flexibility is needed in the direct retainer. Because of its flexibility, it may easily be applied and adjusted to the partial denture.

It is sincerely believed that by the use of splinting and full coverage of the abutment teeth, a very inadequate abutment area can be changed to a useful abutment area. In this way, the rather hopeless situation of having only the anterior teeth to support the partial denture will be forestalled.

ALTERNATE PLANS*

Alternate plans for mouth preparation of the Class I situation where the premolars are not considered strong enough to carry the additional abutment stresses include: (1) the shifting of the occlusal stop forward to the cuspid in order to reduce the effect of additional leverage, and (2) the bypassing of weak teeth.

Both of these plans have in effect been anticipated in the initial design by using the cuspids as the main stabilizers and guides of occlusion.

The shifting of the occlusal stops forward reduces the stresses on the weak distal abutment teeth, and minimizes the forward movement of the lingual bar, thus reducing impingement on the soft tissues. This principle is particularly true if the partial denture is allowed to go unserviced, for example, by neglecting to reline the bases when the residual ridge changes. The direct retainer becomes an indirect retainer. The indirect retainer is now in the same position as the fulcrum line.

Rationale.—By shifting the occlusal rests forward and designing both sides of the arch approximately the same in length and balance, the clasps on the second premolars become passive and kind to the weak teeth. The continuous clasps act as splints, thus preventing the premolars from drifting. It is likewise true, as in the alternate plan of bypassing, that when the premolars are removed, they may be supplied on the partial denture.

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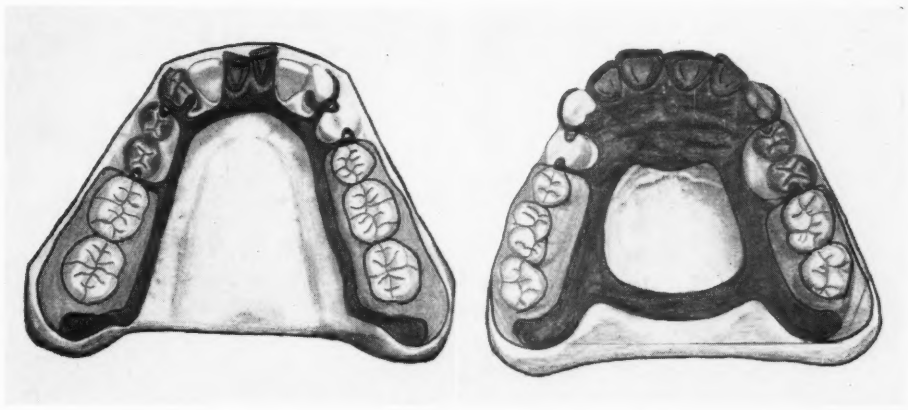
*Steffel, Victor, L.: Postgraduate course in Partial Denture Prosthodontics, Feb. 18-22, 1957, Ohio State University, and described by Phillips, Robert N.: A Problem of Retention in a Lower Partial Denture, J. PROS. DEN. 6:213-219, 1956.

KENNEDY CLASSIFICATION IV SITUATION

If, at any time while the patient is wearing this partial denture, some of the anterior teeth are lost from disease or accident, they may be replaced by merely adding to the partial denture in that arch (Fig. 8,*A*). However, as in Class I and II, the more teeth and supported structures lost, the more leverage stresses developed.

In the maxillary Class IV partial denture, the preservation of supporting structures is imperative because of the labially directed stresses during mastication (Fig. 8,*B*). For this reason, it is essential to maintain continuous support of the denture bases by adjustments and relining.



A. *B.*

Fig. 8.—*A*, A modification of the mandibular partial denture to provide for subsequent loss of anterior teeth (Kennedy Classification IV).
B, A modification of the maxillary partial denture to provide for subsequent loss of anterior teeth (Kennedy Classification IV).

SUMMARY

To meet the challenge of the partially edentulous mouth, the combined current thinking of some of the leading prosthodontists has been merely molded into a long-range treatment plan. The philosophy of this treatment is based on the simple rigid clasp-retained partial denture, which can be constructed and maintained by most dentists for the majority of their partially edentulous patients.

The three major objectives are: (1) the economic consideration of the treatment for the patient, (2) the avoidance of unnecessary duplication of effort, and (3) the prolongation of the partially edentulous period for the patient.

A hypothetical clinical series of various stages of degenerative dental diseases for partially edentulous patients, progressing from Class III to Class II to Class I and to Class IV of the Kennedy Classification, has been used to illustrate long-range partial denture planning. This treatment is not merely adding teeth to an appliance. It is rather the control of the total stress loads by keeping them to a minimum and within the tissue tolerance and health of the patient. In approaching these three objectives, a long-term prosthodontic service is offered. Emphasis is placed

on a continuous consideration of the total welfare of the patient. The dental destiny of the patient is in the hands of the dentist where it should be. The dentist alone, by virtue of his training and experience, is capable of assuming this responsibility.

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FUNCTIONAL OCCLUSION IN REMOVABLE PARTIAL DENTURE CONSTRUCTION

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IT HAS BEEN STATED that occlusion is dentistry, and there are not many prosthodontists, periodontists, and orthodontists who will take issue with the statement. Yet, occlusion has long been one of the most neglected aspects of partial denture construction. This neglect results, in part, from a lack of understanding of the complexities of partial denture occlusion and probably also to the fact that occlusion on most partial dentures is established according to a static jaw relation record only. This meager relationship afforded by the dentist is a limitation imposed upon the laboratory technician.

It is claimed that the functional relationship of the partial denture to the natural dentition may be adjusted satisfactorily in the mouth, but I doubt that this is or can be done adequately. Partial denture occlusion thus established can at best only perpetuate malocclusions which existed previously and help to maintain the existing vertical relationship, however inadequate it may be.

Too many partial dentures are built to one extreme or another. Either they have a negative occlusal relationship with the opposing teeth, and as such only fill a space without providing any occlusal support or balance, or they have a balanced occlusal relationship with the opposing teeth in centric occlusion, but with occlusal disharmony in eccentric positions. A negative relationship, which is the least harmful of the two, can be demonstrated easily by having the patient close on a thin sheet of a soft wax and comparing denture tooth contacts. Disharmony in other than centric positions can be demonstrated easily by palpating the buccal surfaces of the opposing teeth for movement while eccentric contacts are made. Usually, such tooth movement can be demonstrated visually, if one will only look for it.

Balanced occlusion is desirable in complete dentures because occlusal stresses may cause instability of the dentures and even trauma to the supporting structures. And yet, these stresses can reach a point beyond which movement of the dentures takes place. The stresses are broken at the expense of denture stability and retention.

In partial dentures, however, because of the fixation to abutments, occlusal stresses are transmitted directly to the abutment teeth and other supporting structures, resulting in sustained stresses which are far more damaging than those

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transient stresses found in complete dentures. Therefore, occlusal harmony between a partial denture and the remaining natural teeth is a major factor in the preservation of the health of their surrounding structures.

In the fabrication of complete dentures, only one factor, the inclination of the condyle path, is not within the control of the dentist. All other factors may be altered to obtain occlusal balance and harmony in eccentric positions within the scope of the dentist's concept and philosophy of occlusion.

In establishing occlusion on the partial denture, the influence of the remaining teeth is usually such that the occlusal forms of the teeth on the denture must conform to an already established occlusal pattern. This occlusal pattern may have been improved upon by occlusal equilibration or rehabilitation, but the pattern present at the time the partial denture is made dictates the occlusion on the partial denture.

The only exceptions to this fact are those where an opposing complete denture can be made to harmonize occlusally with the partial denture, or where only anterior teeth remain in both arches and the incisal relationship can be made noninterfering. In these situations, the recording of jaw relations and the arrangement of the teeth may proceed in the same manner as with complete dentures and the same general principles apply.

With all other types of partial dentures, the remaining teeth must dictate the occlusion, unless we are willing to accept nothing more than centric occlusal contacts and ignore lateral interference, or have reason to believe that we can achieve occlusal harmony on the partial denture by adjusting the occlusion in the mouth.

METHODS OF ADJUSTING INTEROCCLUSAL RELATIONS

Beckett[1] describes four ways of establishing interocclusal relations for partial dentures; Osborne and Lammie[2] likewise list four methods, but somewhat differently. The simplest but least accurate method is that in which sufficient upper and lower teeth remain in contact to make the existing jaw relationship obvious and when only a few teeth are replaced on short denture bases. Casts are articulated by hand, and occlusion on the finished denture is corrected in the mouth with the aid of articulating paper. Even the periodontists would criticize this method without occlusal analysis of the combined dentition. At best, any existing malocclusion and lost vertical relation may be perpetuated by this method.

A second method, which is a modification of the first, is used when sufficient teeth remain to support the partial denture but when correct relating of the casts by hand is uncertain. Occlusion rims, preferably with occlusal rests, are used to accomplish the same thing as in the first method, and all eccentric tooth interference is removed on the finished denture after it is inserted in the mouth. In either method, the use of a wax interocclusal record between natural teeth is to be condemned because of the influence of the consistency of the wax and the errors which may occur while relating the casts.

When there are no opposing posterior teeth, a third method may be used. This calls for the use of accurate bases upon which an interocclusal relation can be established in harmony with the centric occlusal contacts of the remaining teeth.

If a wax interocclusal record may be inaccurate in recording tooth relationships, it will be even more so on free-end bases, because the wax record can cause the displacement of soft tissues. Modeling composition occlusion rims are preferred because they can be uniformly softened by flaming. It is still better if the occlusion rims are reduced in height about one-eighth of an inch and serrated and then soft plaster of Paris or zinc oxide and eugenol impression paste is used as the final recording medium.

When no occlusal contact exists between the remaining natural teeth, all interocclusal registrations are made upon the occlusion rims. The occlusion rims must be built upon accurate bases, and modeling composition is much preferred over wax, although either may be used. The choice of method for recording jaw relations is much the same as for complete dentures. Either a static relation or an intraoral stylus tracing may be used. As in complete denture construction, the use of a face-bow, the choice of articulator, and the recording of eccentric jaw positions for purposes of adjusting the articulator elements depend upon the philosophies, the training, and the ability of the dentist.

The same principles of occlusion apply as with a complete denture, whereas with all methods previously outlined, the use of a face-bow and adjustable articulator would be ridiculous. If the dentist believes he can adjust the occlusion adequately in the mouth, a simple hinge mounting is all that is needed. On the other hand, if he believes in the use of an adjustable hinge axis instrument, then he should use it. However, comparatively few dentists do so.

The fifth method of establishing occlusion on the partial denture is the method described by Applegate.[3] This method involves the generation of occlusal paths and the use of an occlusal template to which the denture teeth are occluded and by which they are modified to accept eccentric movements. Thompson,[4] although speaking as an orthodontist, has placed the emphasis on occlusion as follows: Observing the occlusion with the teeth in static relations and then moving the mandible into various eccentric positions is not sufficient. A dynamic concept is necessay in order to produce an occlusion that is in functional harmony with the facial skeleton, the musculature, and the temporomandibular joint. To this we need only add, "And with the remaining natural teeth," and we have defined the requirements for partial denture occlusion.

ESTABLISHING OCCLUSAL HARMONY

The establishment of occlusal harmony begins with an analysis of the existing occlusion and the correction of existing occlusal disharmony as a necessary step in the mouth preparations for any partial denture. The resulting occlusion is the occlusion which we strive to transfer to an instrument in such a manner that disharmony on the partial denture is prevented.

In this method, an occlusion rim of an especially suitable hard wax is attached to an accurate base which is either attached to the partial denture framework or supported by a cast metal base. This method presumes that either an opposing denture or natural dentition is present. Should partial dentures be necessary in both dental arches, a choice must be made as to which denture is to be made first on a simple articulator mounting and which denture is to have the functional oc-

clusal pattern. This occlusion rim is worn by the patient for a period of time, preferably for 24 hours or more and preferably during sleep. It is removed by the patient only while eating.

DEVELOPING OCCLUSAL PATHWAYS

By wearing and biting into this wax occlusion rim, a record is made of the opposing teeth in all extremes of jaw movement (Fig. 1). It is necessary that the wax occlusal surface of the rim be adjusted at the chair to maintain positive contact during all excursions and that it be left high enough to assure that a record of each cusp in movement is carved in the wax. This record includes not only the voluntary excursive movements but also the involuntary movements, such as nervous habit patterns and changes in jaw movement caused by changes in posture. Extreme jaw positions and habits occurring during sleep should also be registered.

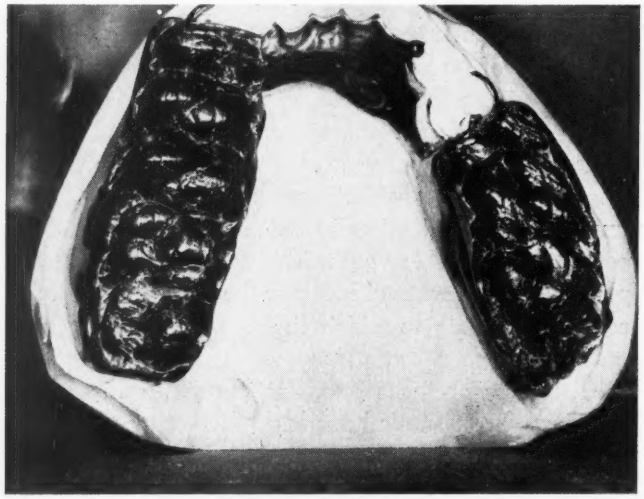

Fig. 1.—An occlusal registration of the opposing dentition is made in wax. This is a dynamic, rather than a static, record of the shape of the opposing teeth.

The occlusal paths, thus recorded, will represent each tooth in its three-dimensional aspect and, although the cast poured against this record will resemble the opposing teeth, it will be much wider than the tooth which carved it because it represents a tooth in all extremes of movement. The recording of occlusal paths in this manner eliminates the problem of trying to reproduce mandibular movement on an instrument.

These movements are made more complicated by the influence of remaining natural teeth. Occlusal harmony in complete dentures may be obtained by modern instruments and techniques. Occlusal harmony in complete mouth rehabilitation may be created by the skilled and meticulous dentist. But unless the working surfaces of the remaining teeth have been scientifically equilibrated and rehabilitated, the mandibular movements will continue to be influenced primarily by the remaining teeth.

ADVANTAGES OF MAKING OCCLUSAL PATHS

The occlusion on the partial denture will have more complete harmony with the opposing teeth and the remaining natural teeth by this method than can ever be obtained by adjustments in the mouth, because corrections to accommodate to voluntary movements does not mean complete freedom from occlusal disharmony in postural positions or during stress periods. Also, it is very doubtful that any dentist can interpret articulation paper markings correctly without an occlusal analysis, which brings us back to the need for a complicated instrument as the only alternative to this method.

This method has still further advantages. It makes possible the obtaining of jaw relations under actual working conditions, with the new denture framework in its terminal position, the opposing teeth under function, and an opposing denture, if present, fully seated before jaw relations are recorded.

In some instances, it makes possible the recovery of lost vertical dimension, either bilaterally or unilaterally, where abnormal closure or mandibular rotation has occurred instead of recording and perpetuating an abnormal position which is correctable.

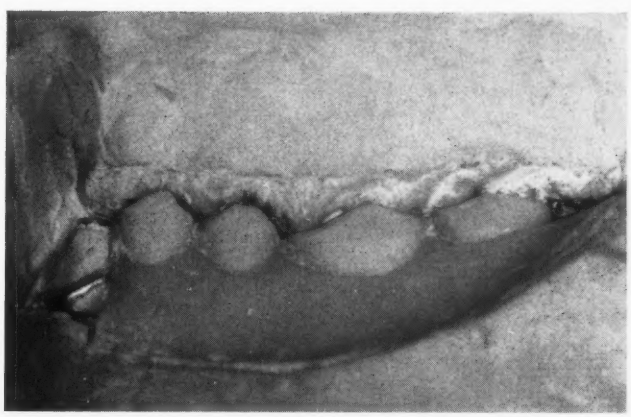

Fig. 2.—Denture teeth are modified to occlude with the metal template. The teeth are set to intercuspate whenever possible, and they are set to the most favorable buccolingual relation with the supporting ridge.

STONE OCCLUSAL TEMPLATE

The occlusal registration thus obtained must be converted to an occlusal template by filling the wax record with a hard stone. It is desirable that stone stops be used to maintain the vertical relation, rather than relying upon some adjustable part of the articulating instrument which might be changed accidentally. Also, by the use of stone stops and by mounting both the denture cast and the template before separating them, a simple hinge or even a tripod instrument may be used, thereby eliminating the use of any but the simplest articulator. The jaw movements having been recorded and transferred to a template, eliminate the need for articulator adjustments.

Usually, the occlusal registration is boxed with clay, leaving only the wax registration and the stops exposed, and the hardest of hydrocals is poured into it to form the template.

The denture teeth, whether porcelain or plastic, are only blocks of material from which an occlusal surface is developed to harmonize with an existing occlusal pattern (Fig. 2). Therefore, the teeth must be occluded too high and then ground to fit the template at a predetermined vertical level. One of the hazards of setting teeth to a stone template is that the template becomes abraded by continuous closure against the denture teeth as they are being ground into occlusion. Some indicater must be used, and typewriter ribbon is much to be preferred over articulating paper for this purpose. It is inevitable that during the process of repeated marking and grinding, the stone template is subjected to considerable abuse and wear. This abrasion can be avoided by electroplating the occlusal registration to make an accurate and indestructible occlusal template (Fig. 3).

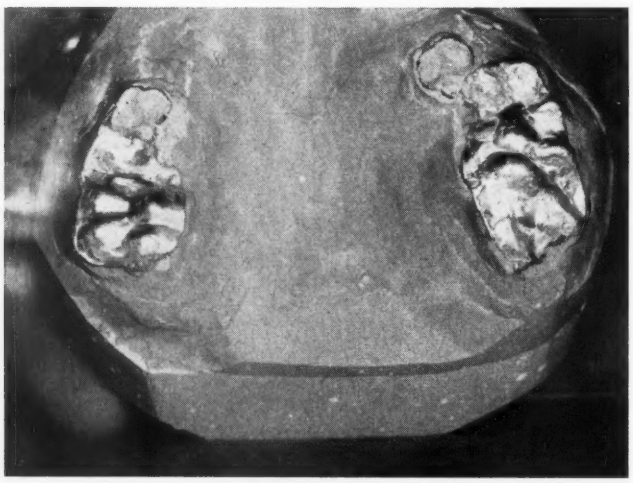

Fig. 3.—The electroformed silver template with two stone stops to preserve the vertical relation.

ELECTROPLATED TEMPLATE

Low-fusing metal has been preferred to stone as an occluding cast material, but molten metal cannot be poured into a wax mold. Electroplating permits a metallic surface to be formed on the wax record with accuracy and with greater hardness than low-fusing metals. Electroforming with silver has proved to be the simplest and most satisfactory method.

Interest in electroplating has been revived since the advent of the Thiokol and Silicone impression materials. The change from time-honored copper dies to silver dies was made necessary by the introduction of these new impression materials when electroformed dies were preferred to stone dies.

The technique for electroplating the occlusal template is basically identical with electroplating of Thiokol and Silicone impressions. The main differences are

that the vessel containing the electrolyte must be larger, the leads must be attached bilaterally in a manner that will allow the denture to be suspended in the solution, and the denture framework must be protected from the electrolytic current.

Ten milliamperes of current per tooth, plus 10 for the leads, is sufficient. Greater amperage would cause the electroplating to be too soft. The total area of the anode immersed in the solution should not be more than twice the area to be plated. The distance from the anode to the surface to be plated should be about 4 inches.

Since the number of teeth involved will vary, the plating machine must have a widely variable output. The machine being used (Fig. 4) is a self-made device with a variable output of from 35 to 200 Ma., although suitable machines ready for use may be purchased.

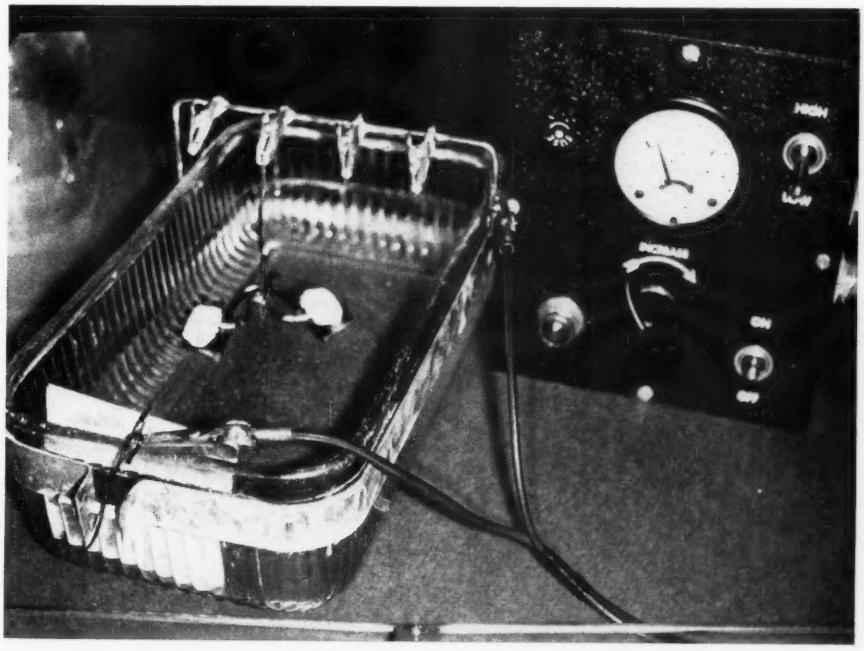

Fig. 4.—The device for electroplating the wax record. The milliamperage can be varied from 35 to 200 Ma. by using variable and fixed wire-wound resistors. The electrolyte is silver potassium cyanide. The anode is pure silver.

The wax occlusal registration is metallized with Staco silver lacquer, and the leads are painted down the lingual side to join with a T-shaped wire lead. This lead is attached to the wax rims with sticky wax (Fig. 5). It is very important that all parts of the denture framework be painted with a protective lacquer, such as Kerr's Plate Mask, to prevent the casting itself from being plated.

At 10 Ma. per tooth, the occlusal registration to be plated should be left in the solution approximately 5 hours. A uniform plate of sufficient thickness will re-

sult (Fig. 6). A heavier plate seems to cause some curling at the edges and pulling away from the wax surface. This leads to inaccuracies and must be avoided. Since the plated surface will be backed up with stone, a thin plate is all that is needed.

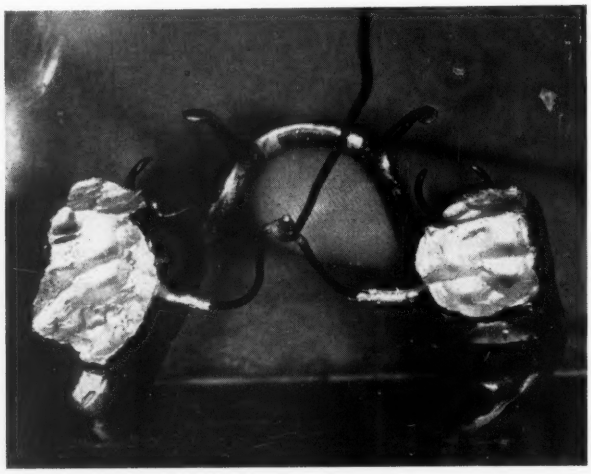

Fig. 5.—The wax record is metallized with a silver lacquer. The leads are attached below the occlusal surface with sticky wax, and the denture framework is coated with protective lacquer.

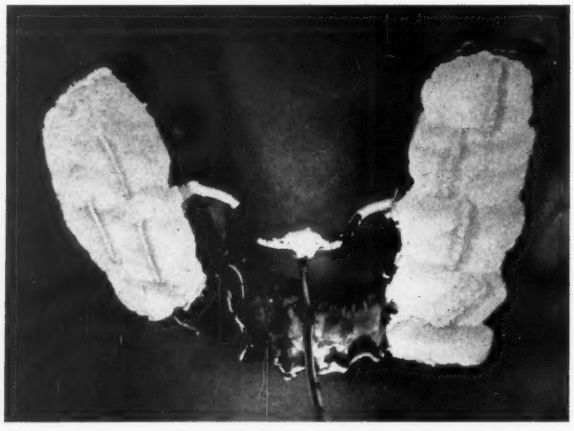

Fig. 6.—At 10 Ma. per tooth, a 5-hour plating time gives sufficient thickness without curling or pulling away.

The attachment of the stone backing to the silver plate was a problem at first. In some cases, the metal separated from the stone backing due to the absence of mechanical attachment. The problem has been solved by imbedding two or more wire staples into the wax surface of the occlusal registration before plating (Fig. 7). These staples become part of the plated surface and aid in securing the metal to the stone. The small tip end of each staple projecting through the metal template can easily be ground away without marring the surfaces of the template.

The plated surface is boxed with clay, and stone is poured against it in the same manner as an unplated wax record. The articulator mounting and occluding the teeth to the template is the same, except for the advantages of the metal surface over a stone surface.

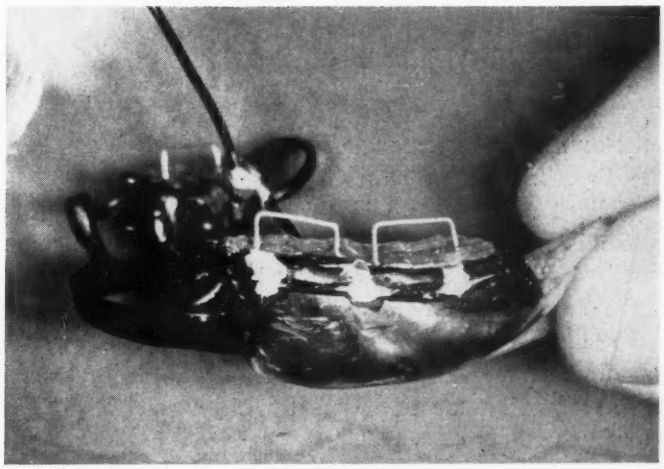

Fig. 7.—Wire staples are imbedded carefully into the wax record, and they become part of the plated surface. They serve to secure the metal template to the hydrocal backing which is poured against it. The staples are of small enough gauge to cause only minor defects in the surface of the template, and these are easily ground away.

CONCLUSION

It is not expected that the silver plating of a wax occlusal record will receive wide acceptance because of the added step of electroplating. But just as there are those who prefer to work with electroformed dies, so there may be some who would prefer to set teeth to a metal template. It is hoped that this procedure will contribute something toward better removable partial denture occlusion.

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REMOVABLE PARTIAL DENTURE TERMINOLOGY

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THE GLOSSARY OF PROSTHODONTIC TERMS,"[1] published in 1956, by the Academy of Denture Prosthetics, represents many years of effort to establish an acceptable and standard nomenclature in this field. We are all grateful for this effort and its tangible results. Significantly, the Glossary was presented as a "progress report" which could serve as a "good temporary standard."[1] Sears had written earlier, "To make our progress more certain, we should from time to time re-examine and refine our terms. Your committee feels that the adoption of the terms now submitted will give us better tools to work with. There is nothing final about these terms, but for the present we can put them to use and continue to work for further improvement."[2]

It was in just this spirit that the Research Committee on Removable Partial Dentures of the Greater New York Academy of Prosthodontics reviewed the 1956 Glossary. This committee reviewed only those terms directly relating to removable partial denture prosthesis. Many of these terms in the original Glossary were judged acceptable.† Others, discussed here, were judged to be unacceptable and requiring review and redefinition. Where deemed necessary, new terms are introduced and defined.

RETENTION AND STABILIZATION

"Retention" and "stabilization" are terms that have been appearing together in increasingly popular usage in dental literature. The delineations and implications of these terms are essential to the comprehension of denture function and to the execution of successful denture service.

Of the two terms, "retention" has been in common usage for a longer period of time. Time, however has not automatically conferred greater clarity or universal acceptance to its meaning. Cummer[3] described "retention" as "the fixation of the piece in the mouth in such a manner that it is easily removable by

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This is a report by the Research Committee on Removable Partial Dentures of the Greater New York Academy of Prosthodontics. The members of this committee are Dr. Gilbert P. Smith, Chairman, Dr. R. E. Herlands, Secretary, Dr. G. W. Hindels, Dr. W. Campbell Hudson, Sr., Dr. J. T. McGuinn, and Dr. M. H. Rode.

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†Basal seat, connector, minor connector, denture, denture base, partial denture, denture foundation, impression, partial denture impression (def. 1), preliminary impression, sectional impression, removable partial denture, incisal rest, occlusal rest, survey line (def. 1).

the patient for cleansing, yet may be replaced by the patient and retained in the mouth with sufficient firmness and without injury to the remaining structures during function." Applegate[4] described "retention" as simply "resistance to dislodgement." Swenson and Terkla define "retention" as "The fixation of a dental prosthesis in position."[5] The influence of these thoughts is seen in the definitions of "retention" in the Glossary[1]: "1. The fixation of a dental prosthesis in position. 2. The means by which a removable partial denture is maintained in a functional position."

The test of the validity of a set of definitions, we are told by authorities in the field of logic, is which one "lays bare the principle features or structure of the concept"[6] which makes it definite and delimits it from other concepts.. In addition, which one so expresses the *essence* of that which is defined that it serves better as a premise for further study or clinical application.

It is interesting, therefore, to compare these definitions with those representing a functional and analytic approach. Frechette[7] equates "retention" with "resistance to dislodging vertical force." DeVan[8] further limits the quality of resistance by restricting it solely to "countersaddlewise vertical forces, such as the force of gravity in an upper partial denture and the pull of sticky foods." Craddock[9] shares DeVan's views and describes the retaining of a denture "against the displacing force of gravity and of sticky foods."

The words "fixation" and "dislodgment" do convey some of the overtones in the concept of retention. As used in the first sets of definitions, without further explanation or modification, the concept is incomplete and may be misleading. A removable partial denture is not "fixed" in position in the same sense as, for example, is a fixed partial denture. On the contrary, increased emphasis is being placed on minimal retention following the securing of maximum stabilization. As Smith[10] wrote, "Once stabilization is secured, retention of the partial denture does not present a serious problem." Similarly, "dislodgment," used alone, is a vague term. Although probably meant to describe resistance to movement *away from* the remaining teeth and mucosa, this is not explicitly stated. Dislodgment can and does occur in response to forces associated with jaw closure.

These forces generated by mastication and transmitted to the denture, and ultimately to its foundation, have many vectors, e.g., vertical, horizontal, and rotational. To stabilize a denture means to so design and construct it that the denture resists these stresses. "Stabilization" is a more generic and inclusive term that has, to a large extent, replaced the terms "support" and "bracing." "Support" has been used synonymously with vertical stabilization, whereas "bracing" has usually meant lateral stabilization.

The definition of "stabilization" in the Glossary is *"the seating** of a fixed or removable denture so that it will not tilt or be displaced under pressure"[1] was judged unacceptable. Stabilization and retention are denture *qualities* which should be described in terms of the forces or stresses that they counteract or dissipate; stresses associated with both opening and closing of the jaws. Understanding these differences enables us to delegate the proper role to the various components

*Italics by the author.

of a denture and its retainers. The definitions proposed by the committee are as follows:

retention (As applied to removable partial dentures.) That quality inherent in the denture which resists the force of gravity, the adhesiveness of foods, and the forces associated with the opening of the jaws.

stabilization (As applied to removable partial dentures.) That quality inherent in the denture which resists stresses placed on the denture by masticatory forces and the forces associated with closing the jaws.

Credit should be given to Gillett[11-13] for the source of these definitions. His pioneering work and writings on partial denture design and function are startling in their clarity and validity.

DENTURE STABILITY

The definition of "denture stability" in the Glossary is: "The resistance to the movement of a denture on its basal seat."[1] Following the reasoning expressed above, the committee proposes the following definition:

denture stability The quality of a denture to resist stresses placed on it during masticatory function (or jaw closure) which might cause denture movement.

Jaw closure is meant to include all functional as well as functional closure movements, vertically, or with horizontal components, as in the presence of clamping or grinding habits.

One of the attributes of a valid definition is its value as a premise for further inquiry. This stress analysis of denture stability can be applied with equal effectiveness and cogency to abutment teeth and their prognosis. This has been done in the recent critical discussion of abutment stabilization by Cohn.[14]

PASSIVITY AND RETAINER

The terms "passivity" and "retainer" are discussed together here because they are coupled by definition in the Glossary. "Passivity" is defined there as, "The static condition assumed by a direct retainer after being seated upon an abutment tooth."[1] "Retainer" is defined in the Glossary as: "1. Any form of attachment applied directly to an abutment tooth used for the fixation of the prosthetic restoration. 2. The means by which a removable partial denture is maintained in a functional position."[1]

"Direct retention" is defined in the Glossary as "Retention obtained in a removable partial denture by the use of attachments or clasps which resist their removal from the abutment teeth."[1] Since a "direct retainer," as such, is not defined, it must be deduced to mean the attachment or clasp applied directly to the abutment tooth.

The objection to the definition of "passivity" in terms of the static condition of only the direct retainer is made on the grounds of incompleteness and faulty emphasis. Our ultimate concern is the state of equilibrium or rest of the teeth and other tissues, hard and soft, adjacent and subjacent to the denture. These tissues may not be in such a state of rest or inertia because of stresses induced by denture components other than the "direct retainers." Therefore, we propose the following definition:

passivity The quality or condition of inactivity or rest assumed by the teeth, tissues, and denture when a removable partial denture is in place but not under masticatory pressure.

Thus defined, "passivity" involves not only a static condition of the retaining elements of the denture, but all segments contacting teeth and the basal seat as well.

"Retainer" is a term that has been inherited mainly from the field of fixed partial denture prosthesis. It has been used by Tylman[15] to mean "that part of a dental bridge which unites the abutment tooth with the suspended portion of the bridge. It may be an inlay, partial veneer crown or a complete crown." It is this meaning to which definition (1) of the Glossary refers. This usage merits continuation in the areas of both fixed and removable partial dentures. We propose the following definition:

retainer A restoration placed in or on an abutment tooth, uniting the abutment tooth with the restoration.

The so-called "retainer," in the sense referred to in definition (2) of the Glossary, in a clasp-type denture, is, in reality, only that flexible portion of the clasp that engages an undercut on the coronal surface of the abutment tooth. It is recommended that the term "retentive arm" be used as a substitute for the term "retainer" when used in this special sense. The committee proposes the following definition:

retentive arm A flexible segment of a removable partial denture that engages an undercut on the abutment and is designed to retain the denture.

It could be said, then, that denture retention is secured by the placement of retentive arms of clasps against favorable tooth contours, these contours being those of natural tooth surfaces or the surfaces of retainers placed upon them.

FULCRUM LINE

"Fulcrum line" is defined in the Glossary as "an imaginary line drawn through the load areas of teeth with direct retainers around which line the denture tends to rotate under masticatory stress."[1] This rotational response of the denture to masticatory load, it is true, is due to the existence of occlusal rests located adjacent to tissue-borne denture bases. It is not true, however, in the case of entirely tooth-borne removable partial dentures. Moreover, rotation tends to occur upon jaw opening as well as jaw closure (masticatory stress), especially in the case of distal extension removable partial dentures.

Applegate[16] considered "fulcrum line" as "a line extended through the occlusal rest areas of the principal abutments. These supports act as the fulcrums on which the appliance movement occurs as the base extended in one direction tends to leave the supporting tissue and those units of the appliance on the opposite side tend to move toward the teeth or tissues." Does the denture actually rotate around a line connecting both occlusal rest areas after the rest has moved occlusally away from the rest seat? The fulcrum line must *then* be transferred to some other point of tooth contact, namely, the terminal points of the retentive clasp arms.

The term "fulcrum line" can be used in its most general sense. When describing denture rotation as a response to specific stresses, however, we should

make a distinction between tooth-denture contacts that come into play under masticatory stress and those which are activated upon jaw opening. The committee, therefore, recommends the following definitions:

fulcrum line An imaginary line around which a removable denture tends to rotate.

retentive fulcrum line An imaginary line connecting the retentive points of clasp arms on retaining teeth adjacent to tissue-borne denture bases.

stabilizing fulcrum line An imaginary line connecting occlusal rests adjacent to tissue-borne denture bases.

BAR, INDIRECT RETAINER, CONTINUOUS BAR RETAINER

The noun "bar" has been used most often with some modifying adjective to denote the connection between component parts of a removable partial denture, as, for example, palatal bar or lingual bar. In this common usage, "bar" is meant to be a type of major connector. The definition of this term in the Glossary as "a segment or unit of a partial denture"[1] was felt to be too general. The committee therefore submits the following definition:

bar A metal segment of greater length than width connecting two or more parts of a removable partial denture.

"Bar" is sometimes employed as an adjective, as in "bar clasp arm" or "continuous bar retainer," to denote a bar-type denture segment of specialized function. This function may be primary retention or indirect retention.

"Indirect retainer" is a term that has survived over the years and may well continue fixed in prosthodontic terminology. An indirect retainer is not a retainer in the sense expressed by previous definition. Logically, it would appear to be related to retention because of its action in countering stresses arising from jaw opening. It can be effective, however, under only one circumstance, namely, the existence of a retentive fulcrum line. In the case of maximal length frictional attachments or other keyed recessed rests, denture rotation may be countered to such degree as to obviate the need for indirect retainers.

The Glossary defines "indirect retainer" as "that part of a removable partial denture which assists the direct retainers in preventing free-end denture base displacement by functioning indirectly on the opposite side of the fulcrum line."[1]

Since indirect retention is of assistance under the special conditions of a clasp-type denture employing retentive clasp arms and the existence of a retentive fulcrum line, the committee submits the following definition:

indirect retainer A device placed on the opposite side of the retentive fulcrum line from the denture base.

An indirect retainer aids in denture retention by countering denture rotation round the retentive fulcrum line. These devices may be of several types, two of the most common varieties being: (1) slender bar-type extensions resting on the incisal, occlusal, or lingual surfaces of teeth (Cummer)[17]; (2) a continuous bar retainer, sometimes referred to as a "double lingual bar" (Kennedy),[17] or a "continuous clasp or strap" (Standard).[18] The exact function, action, and design of the "continuous bar retainer" has, in the words of Standard,[18] "created con-

siderable controversy." There has been much argument concerning the value of the continuous bar retainer as an indirect retainer and much more confusion concerning its merits as a denture and/or tooth stabilizer.

The Glossary defines "continuous bar retainer" as: "A metal bar, usually resting on lingual surfaces of teeth, to aid in their stabilization and to act as indirect retainers."[1]

The committee is of the opinion that this definition is vulnerable in its first part and overly optimistic in its second part and, therefore, submits the following definition:

continuous bar retainer A metal bar which contacts lingual surfaces of anterior teeth and aids in the retention of a distal extension partial denture.

The proper function of a continuous bar retainer depends on the existence of denture rotation around the retentive fulcrum line.

CLASPS

A clasp may be defined in terms of its shape, location, components, and function. We agree with the Glossary that functional considerations are primary. An understanding of clasp function forms the basis of designing clasp components in accordance with their intended roles. Since mutual stabilization of denture and abutment teeth is a prime factor in denture planning, a considerable de-emphasis should be made as to the retentive properties of clasps. Retention is relatively easy to secure but difficult to control. Unreciprocated clasp flexion coupled with minimal tooth stabilizing contacts are a common cause of denture failure. Any tooth against which a retentive clasp arm is placed must always be contacted simultaneously by a stabilizer to counteract any potential tooth movement. This reciprocator may be a deeply recessed stabilizing rest, or an extension from the major connector so designed as to contact the abutment tooth throughout the flexing stroke of the buccal arm, or most commonly, it is a rigid lingual clasp arm. These stabilizing contacts also perform the essential task of insuring denture insertion and withdrawal along a positive, predetermined path. It has not been sufficiently emphasized that tooth contours (and any denture contacts with them) have significance in direct ratio to the predictability of this path. A "clasp" is defined in the Glossary as: "1. A part of a removable partial denture which acts as a retainer and/or stabilizer for the denture by partially surrounding or contacting an abutment tooth. 2. A retainer of a removable partial denture, usually consisting of two arms joined by a body which connects with an occlusal rest. At least one arm of a clasp is usually in the infra-bulge area of the tooth enclosed."[1] Except for the phrase "retainer and/or stabilizer," this committee accepts definition (1). We recommend that the word "or" be eliminated, and the definition should then read:

clasp A part of a removable partial denture which acts as a retainer and stabilizer for the denture by partially surrounding or contacting an abutment tooth.

Definition (2) in the Glossary is not acceptable, and we recommend that it be deleted from the Glossary.

BAR CLASP, CIRCUMFERENTIAL CLASP

Among other things, a clasp consists of clasp arms. Clasp arms vary in their origin, course, length, and action. The two main types of clasp arms are the "bar clasp arm" and the "circumferential clasp arm." These arms, or variations of them in a multiplicity of shapes, may be so designed and placed against suitable tooth contours that they successfully perform the functions assigned to them.

Neither of these clasp arms (bar or circumferential) is defined in the Glossary. We are therefore submitting the following definitions:

bar clasp arm A clasp arm which has its origin in the denture base or major connector. It consists of an arm which traverses but does not contact the gingival structures and a terminal end which approaches its contact with the tooth in a gingivo-occlusal direction.

circumferential clasp arm A clasp arm which has its origin in a minor connector and which follows the contour of the tooth approximately in a plane perpendicular to the path of insertion of the partial denture.

stabilizing circumferential clasp arm A circumferential clasp arm which is rigid and engages the height of contour.

retentive circumferential clasp arm A circumferential clasp arm which is flexible and engages the infra-bulge at its terminal end.

The term "circumferential clasp" implies a clasp consisting of two circumferential clasp arms. This is true but does not mean to imply that one of these clasp arms must always be of the retentive type as stated in the Glossary as follows: "at least one terminal being in the infra-bulge area."[1] There are clinical situations where it is advantageous to use two stabilizing circumferential clasp arms on the same tooth, providing that adequate retention is secured elsewhere. We therefore have substituted the following definition:

circumferential clasp A clasp consisting of two circumferential clasp arms, both of which originate from the same minor connector and are located on opposite surfaces of the abutment tooth.

The term "bar clasp" presents quite a different problem. It is defined in the Glossary in words analogous to the definition of a circumferential clasp, that is, "consisting of two or more separate bar arms located opposite to each other on the tooth."[1] In order to achieve the proper reciprocation under these conditions, one of these clasp arms must flex, to quote Smith, "simultaneously and with equal pressure—a difficult if not impossible feat."[19] Hindels has stated that both the functions of retention and stabilization cannot be assigned to the same clasp arms. He states, "Since stabilization is associated with rigidity, and retention with flexibility, it cannot be expected that any one element would be able to perform both of these contrary functions as well as it should."[20] Therefore, we feel that the term "bar clasp" is objectionable and recommend its exclusion from the Glossary. The term "bar clasp arm" should be in the Glossary and used as defined previously.

RESTS

Since the concept of stabilization is intimately related to a discussion of rests, it will be profitable to review the definitions of "stabilization" and "denture stability"

presented earlier in this article and in particular the statement that "jaw closure is meant to include all functional and afunctional closure movements, vertically, or with horizontal components."

Rests are not the only stabilizing elements of a removable partial denture, but by their location and design, they can be called upon to perform specialized functions of great necessity to efficient denture service. The type of rest employed in a specific situation depends upon the particular stabilizing contact that is desired.

A "rest" is defined in the Glossary as: "An extension from an appliance that affords support to a restoration."[1] Since "support" in its more precise meaning of "vertical stabilization" is only *one* of the types of stabilizing tooth contacts available by its use, this definition was considered incomplete. The committee therefore recommends the following definition:

rest A rigid stabilizing extension of a partial denture which contacts a remaining tooth or teeth.

Rests may be further classified according to location, depth, or function as follows:

Location: as for example, incisal rest, occlusal rest, or lingual rest.

Depth: as for example, surface rest (which is an extracoronal rest) or recessed rest (which is an intracoronal rest).

Function: as for example, (a) Vertical stabilizing rest: a rest that directs forces mainly along the vertical axis of a tooth. (b) Lateral stabilizing rest: a rest that dissipates lateral stresses by virtue of rest surfaces essentially parallel to the path of insertion of the partial denture. (c) Lock-type stabilizing rest: a keyed rest which prevents drifting of the denture base away from the abutment tooth.

SUMMARY

A Committee of the Greater New York Academy of Prosthodontics has reviewed the Glossary of Prosthodontic Terms with reference to terms relating specifically to removable partial dentures. It has presented reasons for rejecting some definitions and has submitted some new definitions. In some instances, the adoption of new terms is recommended.

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A MODIFICATION OF A SPECIAL RETAINING DEVICE FOR PARTIAL DENTURES

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THIS ARTICLE IS A REPORT of 3 years' experience in the use of a coil spring attachment* as a method for retaining removable partial dentures and an evaluation of its use.

THE MODIFIED ATTACHMENT

The retaining device is a metal cylinder which contains a coil spring and a T-shaped cylindrical bar (Figs. 1 and 2), and it has been modified slightly from that described previously.[1] There is an opening in one end of the cylinder through

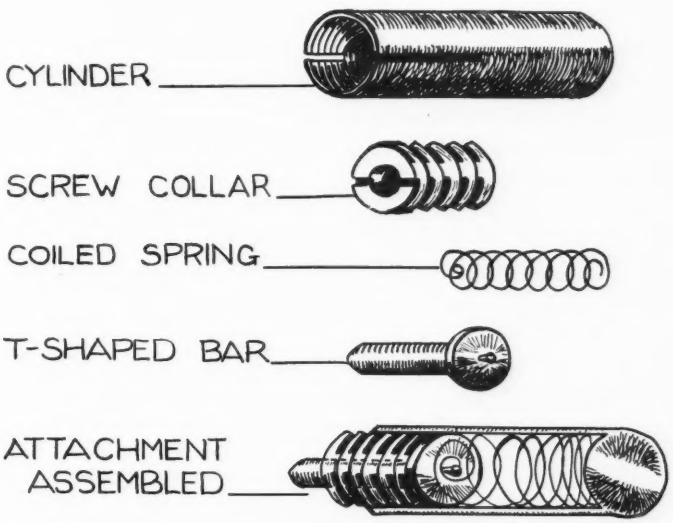

Fig. 1.—A detailed diagram of the modified coil spring attachment.

which a portion of the bar protrudes under the action of the spring. This action is limited by an adjustable screw collar which is set in the opening of the cylinder through which the bar protrudes. The device is constructed of materials which are compatible with the oral fluids. The reason for replacing the lock screw with the

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*TACH-E-Z, Whaledent Inc, Brooklyn, N. Y.

adjustable screw collar (Fig. 3) is to facilitate laboratory procedures and clinical adjustments. A wrench (Figs. 2 and 4) is available to adjust the screw collar.

Fig. 2.

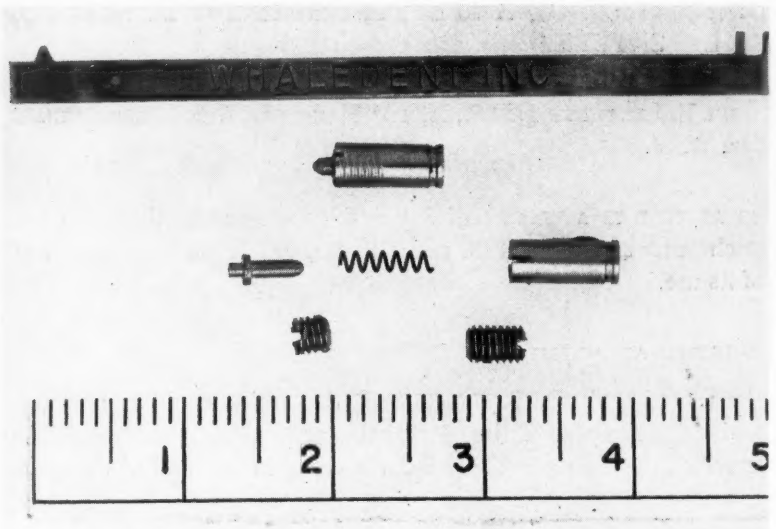


Fig. 3.

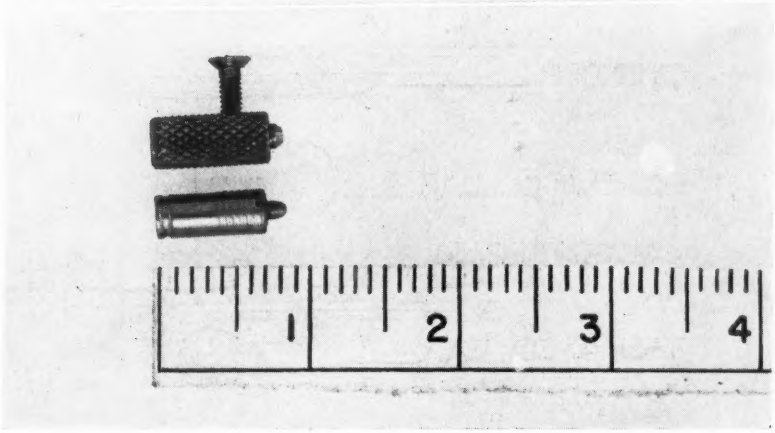


Fig. 2.—The modified coil spring attachment is shown assembled and disassembled. Note the special wrench which is used for assembling and adjusting the device. The size is indicated by the millimeter rule.

Fig. 3.—The earlier attachment is compared to the new modified attachment (mm.).

TECHNIQUE WITH CAST ABUTMENTS

The use of full coverage of abutment teeth, splinting of abutment teeth, and properly balanced occlusion will assist in the protection of natural teeth from caries and periodontal disease. The appliance is favorable for use under these conditions.

The retaining device is either soldered or welded to the metal framework of the partial denture. It is set in such a position so that the tip of the retaining bar

Fig. 4.—The special wrench being used to adjust the attachment.

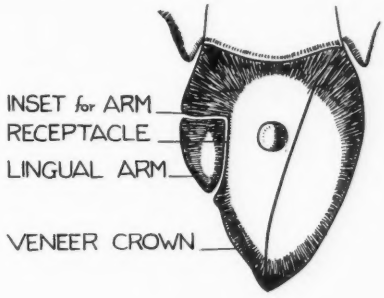


Fig. 5.

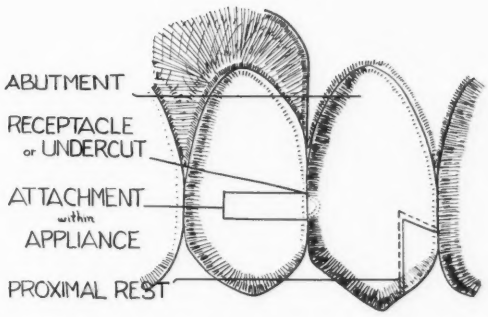


Fig. 6.

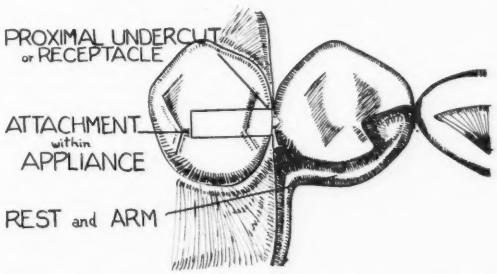


Fig. 7.

Fig. 5.—A veneer crown designed for use with the coil spring attachment.

Fig. 6.—The bar of the retaining device, which is attached to the framework, protrudes and engages a receptacle prepared in an abutment tooth casting, or it may engage a natural tooth undercut.

Fig. 7.—A diagram of the device in the denture base. Note the relationship with the lingual stabilizing arm and the occlusal rest.

protrudes and fits into a receptacle prepared for it in the abutment casting (Figs. 5, 6, and 7). The coil spring attachment for connection to the appliance is positioned so that the bar tip remains in place passively when the denture is seated.

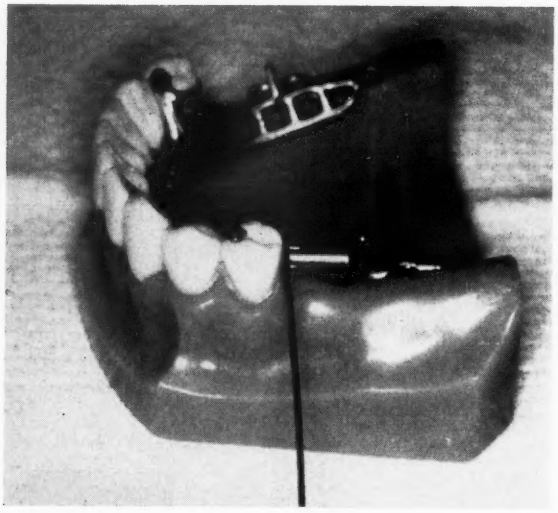


Fig. 8.—The special wrench is used to measure the distance between the cylinder of the attachment and the abutment tooth.

Fig. 9.—The depth of the receptacle in the casting is determined by using the V-shaped tip of the special wrench as a guide.

This is accomplished by placing the cylinder a distance from the abutment casting equal to the thickness of the special wrench (Fig. 8) and making the female receptacle in the abutment casting the depth of the V-shaped tip on the special wrench (Fig. 9). Thus, the sum of these measurements equals the distance that the bar protrudes from the cylinder. In this manner, no pressure is exerted on the abutment tooth when the partial denture is in place. The function of the screw collar is to limit the protrusion of the bar. An occlusal rest must be placed in the opposite

proximo-occlusal angle from the attachment (Figs. 6 and 7) and is received in a rest seat which has been previously prepared in the cast abutment crown (Fig. 10). The rest seat is prepared at right angles to the long axis of the tooth and should be cut as deep as practicable. The main functions of the rest are to transmit occlusal stresses along the long axis of the tooth and to maintain the denture in its predetermined posititon. This will prevent undue tissue displacement by the appliance, which would result in rapid tissue changes. Lateral stresses are opposed by the occlusal rest, a rigid lingual stabilizing arm, and the coil spring attachment. Together, these components encompass more than 180 degrees of the tooth circumference. The lingual arm does not engage an undercut and can be positioned in a previously prepared recess in the abutment casting (Figs. 5 and 10).

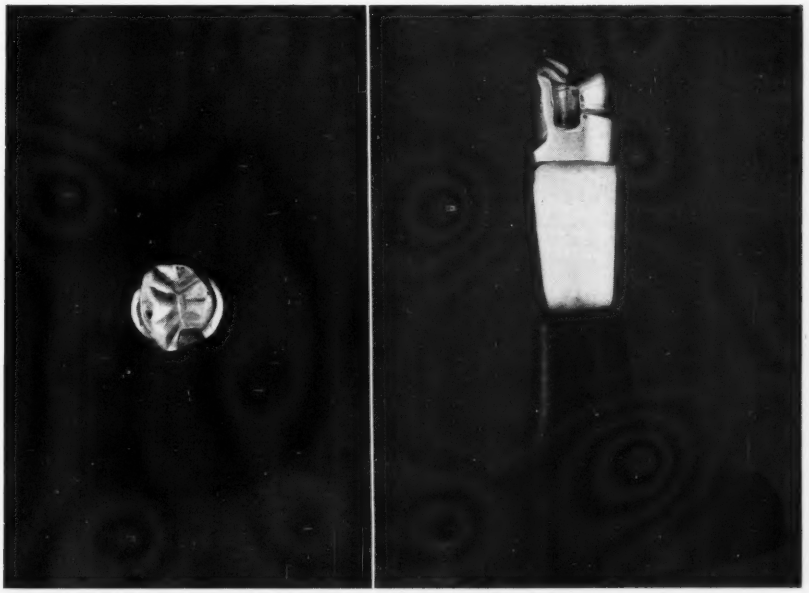


Fig. 10.—An abutment casting showing the relation of the rest seat and the inset for the lingual stabilizing arm.

TECHNIQUE WITH NATURAL TEETH AS ABUTMENTS

In certain cases, the attachment can be used on natural abutment teeth and/or partial coverage of the teeth. A rest seat is prepared at right angles to the long axis of the tooth in the proximo-occlusal angle opposite to the position of the coil spring attachment (Figs. 6 and 7). The attachment engages the natural proximal undercut and is placed so that, once seated, the bar tip remains in place passively, without pressure on the abutment tooth. The lingual stabilizing arm is connected to the occlusal rest and the framework. The principles of opposing forces are satisfied in the same manner as if full coverage restorations had been placed on the abutment teeth.

ADVANTAGES OF THE RETAINING DEVICE

The retaining device eliminates the disadvantages previously encountered with precision attachments, clasps, and combinations and variations of both.

1. The device maintains its relationship to the abutment tooth during function.
2. No part of the device extends onto the labial or buccal surfaces of the abutment teeth, so esthetics of the restoration are improved (Figs. 11 and 12).

Fig. 11.

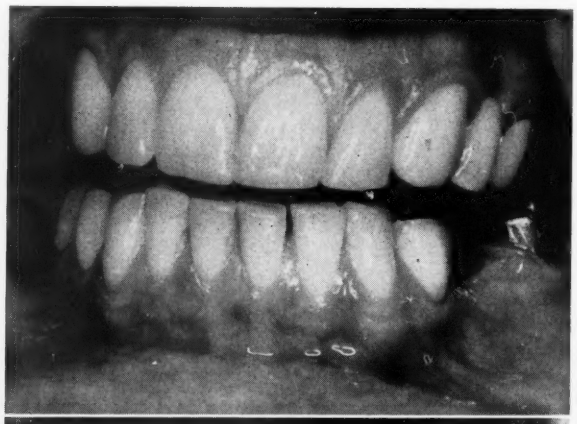


Fig. 12.

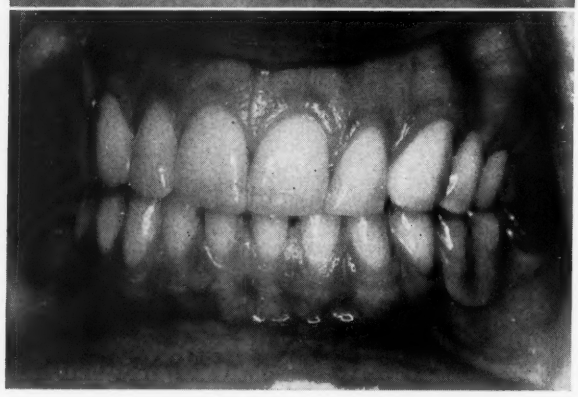
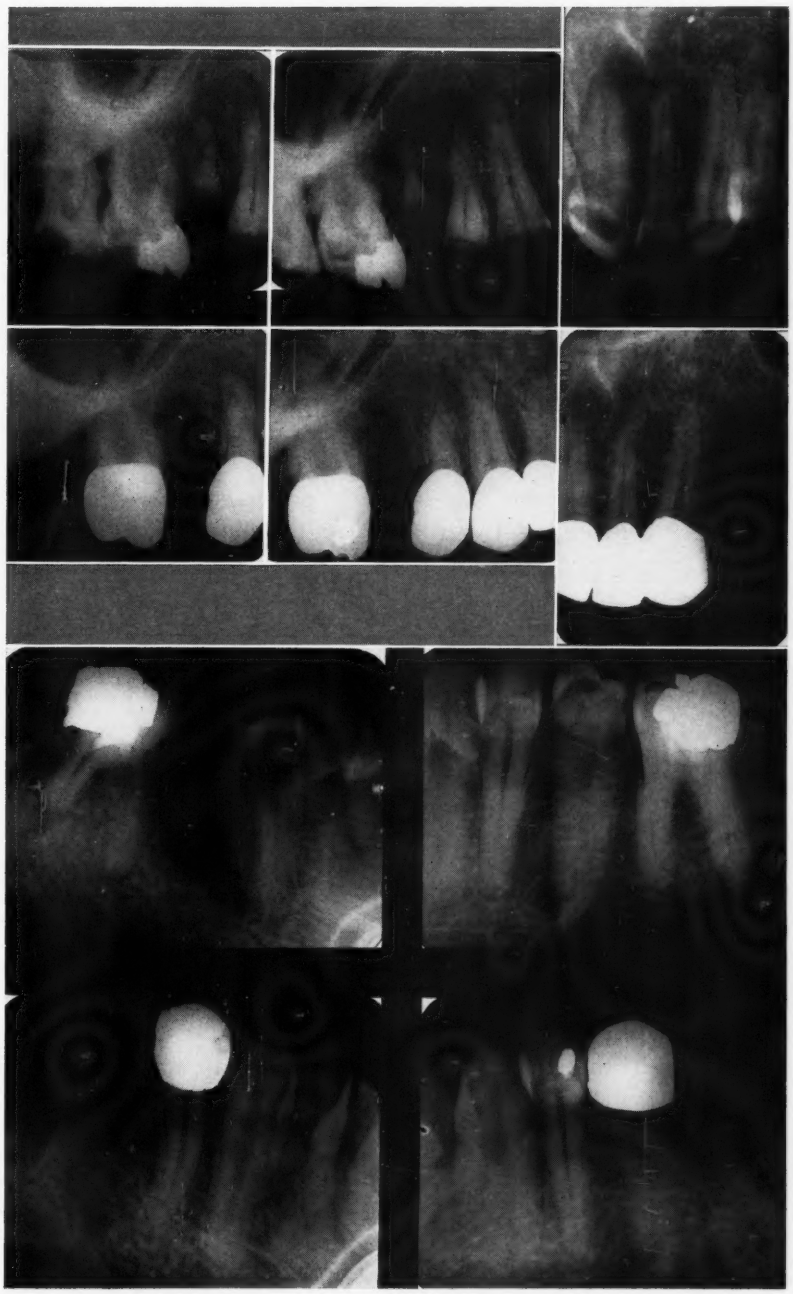


Fig. 11.—Partial dentures retained by the coil spring retaining devices have been worn without damage to the soft tissues.

Fig. 12.—The partial dentures with the coil spring attachments replacing missing teeth shown in Fig. 11 are in position. Note the excellent esthetics and the health of the tissue around the abutment teeth.

3. It is unnecessary to make abutment castings excessively large (Fig. 10).
4. The retaining device can be used even when abutment teeth have very short clinical crowns. No special preparation of the abutment teeth is necessary.
5. Adjustments are rarely necessary.
6. All parts are readily adjustable, removable, and replaceable and never involve laboratory procedures (Fig. 4).
7. The reduction of the size of the contact area on the tooth reduces the susceptibility to caries.

A.



B.

Fig. 13.—Roentgenograms before treatment and after the appliances have been in use for three years, *A*, Upper. *B*, Lower.

8. The use of prepared abutment teeth and castings is optional.

9. No extensive or new clinical procedures are involved.

10. Good oral hygiene is easily maintained by the patient. The exposed portion of the attachment is readily accessible to brushing.[2]

11. Insertion and removal of the partial denture is easy. No auxiliary instruments are necessary.

12. It is impossible for the patient to distort the appliance during insertion or removal.

EVALUATION

A questionnaire was distributed to the dentists who have used this device since early in 1954, in order to assist us in evaluating the efficiency of the attachment. The questionnaires returned showed that the retaining device had been used on 129 mandibular and 68 maxillary dentures. Of these, the devices were used on 189 restorations with cast abutments and 8 restorations with natural tooth abutments, with an average of 2 attachments on each denture. These dentures had been in service an average of one year and eight months, with longest service being three years and four months. An average of less than 1.0 clinical adjustments and no laboratory adjustments were required.

The reports on the questionnaires indicated that roentgenographic observation was consistently negative and showed no apparent bone loss (Fig. 13). Reports of soft tissue observations showed generally good tissue tone except in 6 patients whose poor personal hygiene was a major factor (Figs. 11 and 12).

The patients' reactions were excellent because of the esthetics, comfort, and ease of manipulation of the appliances. The dentists who reported were enthusiastic because of the favorable patient reaction, minimum number of adjustments, and physiologic compatibility of the dentures retained by this device.

SUMMARY

A modification of the coil spring attachment for removable partial dentures has been described. A study of the use of the attachment on 197 dentures has been compiled and a summary of the findings presented. After using this attachment for 3 years, we feel that this retaining device has an important place in prosthetic dentistry as judged by these reports and our own use of it over a period of 3 years.

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FIXED PARTIAL DENTURES

THE THREE "R's" OF GNATHOLOGY

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IN THE FIRST PART of this century, the three "R's" of elementary education were Reading, 'Riting, and 'Rithmetic, and the achievements by students who were given this foundation is a matter of record. All was serene until Professor John Dewey[1] of Columbia University came into the picture of American education and exercised tremendous influence on it. His ideas resulted in a complete upset of the system. Men and women of lesser stature than Dr. Dewey, not educators but educationists, seized upon his philosophy of pragmatism (pedantry), rejected the three "R's," and succeeded in bringing our public school education to its knees by the misuse and misinterpretation of his teachings. The teachers taught methods without purpose, salaries went down, and with it, the quality of teachings and teachers, and it took the Soviet Sputnik with the attendant implications of the launching mechanisms and their adaptation for intercontinental missiles to jar our composure. The satellite in space was a matter of the greatest interest to all, and the astronomers everywhere were occupied in charting its course and making detailed reports of it. With this event came the unhappy realization that the military supremacy of the West was gone and, with it, the confidence in our scientists and the system of education which had produced them.

Today, our President is asking for the largest peacetime national budget in history, including the largest amount of money ever earmarked for education. This sudden vast expenditure for education amounts to a tacit admission of the need for changes in the present system of education. Our present system, influenced by the "instrumentalism" of John Dewey, has been found wanting because of the interpretation and application that has been made of it.

It has produced masses of high school and college graduates unable to use the alphabet, resulting in poor spelling and the consequent inability to make proper use of reference books. The teaching of reading is accomplished largely by word association with pictures, both in textbooks and adult magazines, and none of the American children can escape the impact of the movies and television. To make matters worse, the public school students, with whom I am acquainted, are given television assignments as substitutes for book assignments, and the so-called book reports are made orally rather than in writing. The disciplines of reading

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and writing are given scant attention and, as a result, the college freshman is blamed because he has not developed adequate study habits. This in turn has necessitated the establishment of remedial clinics in most colleges, thus taking precious time from the studies that could have added to his store of knowledge.

Similarly in arithmetic, the public school student does not memorize the times table (the alphabet of mathematics) and, without this, the student is slow in all the mathematical exercises to which he is subjected. This inadequacy persists until such time as he learns the use of the slide rule which then enables him to solve problems quickly. The vast majority of our populace never enjoy this reprieve because they never get to college and, thus, stumble through life making excuses for their own inadequacies; but, as parents, these same people accept no excuses for the poor performances of their children.

The American way of life has been the most successful social formula ever practiced by any large segment of people and has broken with the practice of "what was good enough for my father is good enough for me." It has established the following general pattern of social progress.

The immigrant. He earns his living as an unskilled laborer.

The first generation American. This person earns his living as a skilled laborer.

The second generation American. He earns his living as a participant in the management of business or a profession, which then allows his children, because of the improved economic status, to make a thoughtful choice of their occupation.

DEVELOPMENT OF DENTISTRY

The development of dentistry is closely linked with that of America, for it came into being only as a separate profession, in the city of Baltimore, about 118 years ago. The pattern of dentistry throughout the world is based largely on American dentistry as it is practiced here and now. It is a matter of pride to see the development of high-speed cutting instruments and, with it, the superior cavity and crown preparations with the reduction of pain and hazard to the patient. It is a matter of alarm, however, to have this new tool used for reconstruction rather than rehabilitation. The neglect for the basic need of occlusion could be interpreted as another parallel between dentistry and general education, both the result of Dr. Dewey's[1] theory of "instrumentalism."

It is a matter of general knowledge among dentists that there is excellent service now available to patients in the field of periodontal disease. This includes deep scaling, curettage, pocket elimination, gingivectomy, etc., tooth splinting, and occlusal equilibration. There are many men in this field who write and speak most persuasively and insist that noncusped occlusal surface is adequate for the maintenance of the treated periodontal condition.

FACTOR OF OCCLUSION

However, another group of dentists contends that the occlusal factor becomes even more important following reconstruction if the gnathologic system and the periodontal support are to be maintained at an optimal level. There are many patients who would attest to the fact that the reconstructions in their mouths have

failed, and there are many edentulous patients who are unable to use their dentures successfully. This situation should warrant a sincere effort by clinical investigators and researchers to find a way to reduce the number of these dental failures.

Valiant efforts have been made to find a solution to this problem, and honors are due those who have been brave enough to pioneer new approaches to it. The dental literature seems to indicate that a double problem has been undertaken by most of these men: first, to devise dental restorations that would supply adequate function and esthetics, and second, to devise dental restorations that could be paid for by the patients. This dual-purpose approach has complicated the problem and may have colored the thinking of these pioneers.

An interesting parallel can be drawn between the investigations of medical and dental men in this respect. It is difficult to find in the medical journals allusions to the financial status of patients as a reason for altering a medical treatment. For example, when Sister Kenney, using symptomatic treatment, came to America with possible help in the problem of "polio," every effort was made to raise the needed money so that all who sought help could receive treatment. This treatment, with round-the-clock nursing, was never altered to meet the ability of the patient to pay. At the same time, Dr. Jonas Salk[2] was working quietly, using basic methods of investigation, and came up with the true answer to the problem of poliomyelitis. It is pertinent to the parallel being drawn to remind you of the tragic misuse of the Salk vaccine in the early stages of its administration, as well as of the editorials that were printed about the dangers of it and the strident voices of the opposition on radio and television that were raised against its use. The completed story of the Salk vaccine, however, is happy history. Likewise, it is unfortunate that the opposition voices are halting the general acceptance of the fluoridation program in our fight against caries.

GNATHOSTOMATICS

There is no parallel to be drawn between the death-dealing poliomyelitis and the disturbing discomfort of malocclusion, except in the vast numbers of people affected by both. This example of research procedure has lent impetus to the men who have chosen to follow, right or wrong, their course of investigation in cusped occlusion. This concept of occlusion is based on Gnathostomatics (the function of the contained structures of the mouth and jaws governing the occlusal forms).

ARTICULATORS

At an early stage in the development of restorative dentistry, it was found advantageous to use a machine that could substitute, in measure, for the mouth, and use of these machines (articulators) has continued to the present time. The variations in the design of articulators are infinite, and some of them have provided the dentist with an instrument capable of reproducing the movements of the mouth in action. These articulators have a complicated appearance and, because of their apparent complexity, they have been avoided and sometimes ridiculed by dentists.

The product developed by the use of any articulator depends on the person who uses it. The operator must possess both an understanding of the instrument

and a high degree of skill in the broad field of restorative dentistry in order to produce a superior result. In the 4-year course of a standard dental education, every student is exposed to courses in restorative dentistry including complete dentures, removable partial dentures, and fixed partial dentures. An articulator of some kind is used in every dental curriculum, and its use is explained to the students. One standard articulator has been used at the University of Pennsylvania for the past 10 years, but if a member of the class of 1950 would return today and listen to a lecture on its use, he might reasonably think that he was hearing about a different instrument. The same articulator is used today in conjunction with additional devices which are included to compensate for recognized inadequacies so that it more clearly parallels the actual movements of the mandible than it did. Unfortunately, it still falls short of the goal of perfect synchronization between the action of the muscles of mastication and the teeth in critical areas. This discrepancy requires gross changes in the occluding surfaces of the teeth when the finished restorations are placed in the patient's mouth. This wide armamentarium constitutes another application of "instrumentalism" in dentistry. The restorations made on this instrument are satisfactory in varying degrees and in direct proportion to two factors: (1) the adaptability of the patient, and (2) the skill of the dentist.

While the adaptability of the patient has been the sturdy crutch on which most of the successful restorations have been supported, it is neither logical nor scientific to include it in any evaluation that is made of them. There are limits of adaptability even in the most adaptable of patients; an important example of this is based on the experience of Dykins* relative to impressions for complete denture construction. He has had much to do with the development of mucostatic impressions, which involves the recording of the mucosal covering of the maxillae and mandible at rest. He found that if a casting was made that faithfully reproduced this recorded detail in dentures made on a conventional articulator, the patients invariably were plagued with a denture-sore mouth. If, on the other hand, the impression was less accurate and the denture base material was a plastic or one of the high-fusing metals, the patients with a high degree of adaptability were largely free of complaints, regardless of the articulator or the type of teeth employed.

This was a new-found dilemma to harass a competent dental investigator. He had found a way to make a better impression but was unable to use it. Dykins* now uses mucostatic impressions, which are copied in a low-fusing casting aluminum, for faithful reproduction of detail and, then, in conjunction with an articulator based on Gynathostomatics, is producing restorations that are successful to a most impressive degree. There are others who are using the same procedures with great success, but the number is far too small because the training period is long, the standards exacting, and the cost to the patient is high.

A DIFFERENT APPROACH

Three years ago, a difficult decision was reached by the Faculty of the Dental School of the University of Pennsylvania. It was decided to abandon the time-

*Dykins, William R.: Personal communication.

honored method of *not* teaching occlusion in undergraduate dentistry and to set a program of at least 4 years' duration in which students from the freshman year to the senior year would be exposed to the concepts of gnathology.* This would embrace prosthetic techniques in complete, removable, and fixed partial dentures, and especially tooth morphology, and every effort would be made to integrate the courses in anatomy and physiology with them. It would be the purpose of the Faculty to use the teaching of occlusion as a means of breaking the barriers of departmentalism, and the sage expression "Occlusion is the heart of dentistry" would be the central theme of the teaching program.

POINT OF REFERENCE

The three "R's" of this program have been found to be *Rotation, Retrusion,* and *Relaxation* with the many modifiers of each. It is a matter of record that the terminal hinge axis is the basic starting point of any work to be accomplished in gnathology. This terminal hinge position is the one which allows pure rotation of the condyle in its most retruded position. This rotation is accomplished on a patient only when the patient is relaxed to the point where the mandible swings freely in the hands of the dentist without direction or interference by the patient. This terminal hinge position is a reliable and constant point of reference on most patients who are in good health and free of previous injury to the temporomandibular joint.

Granger[3-6] and others have demonstrated repeatedly the reliability of this terminal hinge position as a point of reference.

This point of reference found on the condyle of the mandible is recorded in relation to the position of the maxillae, with the head of the patient in an upright, unstrained position and with the mandible moving freely in the hands of the dentist. This freedom of movement is not easy to obtain on patients and demands that all of the muscles of mastication be completely relaxed when a hinge axis recording is made. This usually involves the education of the patient by the dentist and, admittedly, there are many patients who are incapable of cooperation to the necessary degree. In these cases, sedation may be used effectively, but it is suggested that the use of warm nonstimulating drinks, massage, and reassuring conversation be employed before resorting to drugs.

DIFFICULTIES

The dentist should avoid the use of force in getting the patient into the terminal hinge axis position if possible. All of us are human, and the patient with a low I.Q., with language difficulties, with bad behavior patterns due to faulty dentures, or with senility may tax all of our resourcefulness, and we find ourselves exerting considerable force on the patient. There are many patients for whom a firm hand is essential to the success of the registration.

Many patients possess the unfortunate ability to drop the condyles from the terminal hinge position to the position of physiologic rest without being aware of

*This program is under the direction of Dr. Ernest R. Granger.

it. The light weight of the hinge bow may cause this phenomenon to occur the instant the guiding hand of the dentist is removed. A hinge axis record made of the condyle in this lower position may be made, but it is not a true point of orientation. If the head is not erect, or if it is slightly forward in position, a patient will find difficulty in attaining this elevated condylar position. Invariably, a patient in the prone position will cause a false terminal hinge position to be recorded for this reason. When attaining the terminal hinge position, the patient must be relaxed, but the head must also be in a position consistent with the needs of his work, social habits, and the very maintenance of life through eating and breathing.

The terminal hinge position assumed when the patient is rotating the mandible freely, in a relaxed condition and in a most retruded and superior position, is a point of reference *only*. No claims are made that function occurs in this position but, rather, function occurs *from* this position. Once the terminal hinge position of reference is obtained, then and only then can accurate protrusive and lateral registrations be made. The mandibular cast must be mounted on the Gnatholator* in centric relation to the maxillary cast for these procedures. The hinge axis is not necessarily synonomous with centric relation, since centric relation is the terminal hinge position at a given vertical dimension.

If any of these factors are wrong, the dentist will soon become aware of it, and the Gnatholator will be unable to accept the protrusive and/or lateral registrations. This serves as an excellent check on the accuracy of the records. The frequency with which the dentist must return to the patient for interocclusal records depends upon the adaptability of the patient and the skill that the dentist has developed through practice.

CURRENT STATUS

At the present time, the first- and second-year students who have been exposed to the theory of gnathology have found it to be not a hardship but, rather, a new use for the anatomy and physiology of the muscles of mastication which they have been taught. The teachers of prosthetic techniques have been rewarded by student enthusiasm for their subject never previously in evidence. The students are spending their spare time in the prosthetic technique laboratory seeking additional information in this intriguing new area of dental teaching.

We have no illusions about having found a solution to all the problems of occlusion, but it is exhilarating to participate in a new program that seems to hold such promise. This promise is based on the results that the second-year students are obtaining in their complete denture techniques. The occlusion of these complete dentures is definitely superior to those produced by any previous student class. Questions come to mind regarding these superior results: Are they due to the enthusiasm of the teachers in a new program? Will the next class produce the same superior results? Does the articulator help produce this better product? Only time and many succeeding student classes will supply this answer.

This new program will be of little moment unless the results are tested thor-

*Designed by Ernest R. Granger.

oughly, objectively, and then evaluated properly. It is our intention to use the newly developed apparatus of Brenman* for these tests. The apparatus permits the making of quantitative occlusal differential determinations by oscillographic interpretations obtained from bone conduction recordings with the patient's head in three predetermined positions that are repeatable. We expect to use this apparatus in conjunction with the cinefluorographic studies of Berry and Hofmann.[7] These objective tests will begin next year when members of the first class that was trained in gnathology will start their clinical practice of dentistry.

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CEMENTATION OF FIXED BRIDGE PROSTHESIS WITH ZINC OXIDE-ROSIN-EUGENOL CEMENTS

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THE CEMENTATION OF FIXED bridge prosthesis with zinc oxide-rosin-eugenol cements (so-called temporary cements) has become a frequently used procedure. The objective of this technique is to allow an unhampered removal of the prosthesis by the dentist when it is deemed necessary. The advantages are numerous. However, clinical experience has shown that there are also disadvantages, and an evaluation of the efficacy of this technique is in order.

The adoption of a zinc oxide-rosin-eugenol method of cementation is prompted by the fact that it provides the dentist with a means of coping with a variety of exigencies that may arise in conjunction with the use of a fixed bridge regardless of the length of its span.

REASONS FOR REMOVING FIXED BRIDGES

If an abutment tooth fails, the fixed bridge may be removed, the offending tooth extracted, and the restoration can be altered and recemented. This obviates the necessity for destroying an expensive restoration in order to unseat it and, by so doing, rendering it useless.

If the patient complains of pain in the area of the prosthesis but cannot localize it, the bridge can be removed to allow clinical inspection and pulp testing of the abutment teeth.

If endodontic treatment is indicated for an abutment tooth, access to the canal(s) is simplified and more accurate when the restoration is not in position.

If the prosthesis has acrylic resin veneers in the labial faces of the gold cast crowns, the instability of their color may promote objectional esthetic qualities over a period of time. Should this occur, removal of the restoration will allow for processing new acrylic resin facings and the restoration of the esthetics.

If the tissue underlying a pontic should become inflamed, this technique provides an opportunity for recontouring the pontic to achieve a more favorable tooth-to-tissue relationship.

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ADDITIONAL ADVANTAGES

The abutment teeth are less sensitive to thermal changes when the prosthesis is cemented with zinc oxide-rosin-eugenol cements than when the oxyphosphate cements are used.

The abutment teeth do not have to be absolutely dry when zinc oxide-rosin-eugenol cements are employed. Their setting is enhanced by the presence of moisture.

The working time of these cements, under normal conditions, is less critical than that of oxyphosphate cement. However, in the presence of high humidity, this advantage may be lost unless the bottles of liquid and powder are kept under refrigeration.

CRITERIA FOR TEMPORARY CEMENTATION

Temporary cementation should be used only with full coverage retainers. The rigidity of the margin of the full cast crown minimizes the possibility of a break in the seal and a washing out of the cementing medium. This may occur more readily with inlay and 3/4 crown types of retainers.

The marginal fit of the crowns must be accurate.

The preparations of the teeth must be retentive by virtue of their parallelism. Preparations that are too convergent are a bad risk for any type of cementation.

In spite of the fact that all of these conditions may be met favorably, there is an element of risk with the use of this method of cementation. The cementing medium can and does wash out. Zinc oxide-rosin-eugenol cement not only lacks the adhesive quality of the oxyphosphate cement, but it is inferior in shearing strength. It never gets truly hard but sets to a rubbery consistency. Thus, when an abutment retainer so cemented is subjected to torque as a result of flexure, the seal may be broken more readily. The danger is obvious, for if the washout goes unobserved by both the patient and the dentist for a period of time, the abutment tooth may become carious, and the pulp may become exposed. Therefore, whenever temporary cementation is utilized, the patient should be apprised, not only of its advantages, but also of the innate risk involved.

The patient should be advised that loosening of the bond about an abutment may be accompanied by a threefold syndrome that is unique to this situation: (1) sensitivity to thermal changes may develop in the area where the cement has washed out; (2) sensitivity to biting pressure may develop in the same area; and (3) a bad taste in the mouth may be noted. If these symptoms become apparent, no time should be lost in returning to the dentist for recementation.

In many instances, the patient may not have any warning, and the washout may go unnoticed by him. Therefore, periodic checkups are an absolute necessity. If, for any reason, this is not possible, this procedure should be discarded in favor of permanent cementation. The only true clinical means for testing for a washout is to remove the bridge. However, a loosening of the bond on a terminal abutment may be detected by applying an unseating pressure with an instrument under the solder joint between the abutment and the adjacent pontic. "Bubbling" of saliva at the gingival margin of the tooth, and an oozing sound indicate a break of the seal.

CAUSES OF WASHED-OUT CEMENT

The loosening of the bond is most commonly observed on a lone terminal abutment that is the only distal support for a span of two or three pontics. This failure may be explained on a purely mechanical basis. As Smyd[1] has pointed out, any span supported by abutments will deflect when subjected to a vertical force. If an entire arch is splinted, the anterior abutments support one another against this flexure. However, a lone terminal abutment must counteract this flexure both by means of the resistance form of its preparation and by the shearing strength of the cement that is used as its bond. More often than not in the splinting of an entire arch, the distal wall of the terminal abutment converges mesially to a greater degree than in a simple crown preparation, in order to achieve parallelism with the anterior teeth. It is also quite common on upper molars that are normally inclined buccally to exaggerate the taper of the buccal wall of the preparation toward the lingual surface of the tooth. This is done to align it with the molar teeth on the opposite side of the arch so as to allow for a common path of insertion of the restoration. Thus, the preparation of the terminal molar abutment in a full arch splint is often quite tapered and lacks the retention and resistance form of an individual crown preparation. This, together with the use of zinc oxide-rosin-eugenol cement and the deflection of the restoration are the prime causative factors in the washouts encountered in these instances.

To help overcome the weakness of the bond, the lone terminal abutments may be cemented with oxyphosphate cement to take advantage of its greater adhesiveness, and the remainder of the prosthesis can be cemented with zinc oxide-rosin-eugenol cement. The rationale for using the "temporary cement" on the intermediate abutments is that, despite the fact that one or two terminal abutments may be permanently cemented, removal of the bridge is still possible. Furthermore, washouts can and do occur with oxyphosphate cement as a result of the same mechanical stresses cited previously.

Crowns of abutment teeth which lack retention form, as a result of decay or previous extensive restorations, should be made as telescope crowns in order to minimize the possibility of breakage of the seal made by the cement. This technique involves the permanent cementation on the tooth of a gold casting which has the external form of an ideal tooth preparation. Over this, the abutment crown may be cemented with temporary cement. Even if the temporary cement is washed out, there is no danger to the underlying tooth because it is protected by the internal gold casting.

Where a fixed splint is utilized in conjunction with a removable precision attachment partial denture, permanent cementation of the attachment abutments is advisable to minimize the danger of unseating the splint as the removable prosthesis is being removed.

The disadvantage of the potential washing out of the temporary cementing medium is outweighed by its many advantages. If the responsibility for maintenance of the fixed restorations so cemented is accepted and fulfilled by both the patient and the dentist, failures as a direct result of this technique can be eliminated.

Another disadvantage of temporary cementation is the deleterious reaction of the eugenol upon acrylic resin restorations. To avoid such contamination, the gold faces of the acrylic veneer crowns must be devoid of openings. If "peep holes" were made at the metal try-in stage to check the accuracy of seating, these should be covered with a low fusing solder before the acrylic resin is processed. If this is not possible, any acrylic resin exposed on the inner surface of the crown should be protected with a silicone lubricant to prevent reaction between the eugenol and the resin. The coating of all exposed acrylic resin with such a lubricant during cementation helps to prevent adverse chemical reactions, and it provides for easier removal of the excess cement. It should be noted that because the zinc oxide-rosin-eugenol cements do not set to a brittle hardness, it is more difficult to remove the subgingival excess than to remove excess oxyphosphate cements. The gingival sulci must be checked carefully to make sure that no cement remains to produce an inflammatory reaction. A zinc oxide paste solvent should be used to make sure that no vestige of cement remains on the acrylic resin parts of the restoration.

SUMMARY

Clinical experience has shown that there is a justification for the cementation of fixed prosthesis by means of zinc oxide-rosin-eugenol cements. The successful employment of a temporary cementation technique depends upon the application of a thorough understanding of its disadvantages as well as its advantages.

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ELECTROFORMED DIES FROM THIOKOL AND SILICONE IMPRESSIONS

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IT IS FREQUENTLY STATED that one of the advantages of the Thiokol and silicone impression materials, as compared to the hydrocolloids, is the ease in which they can be electroplated. Numerous articles have been concerned with copper plating and silver plating of such impressions, but the observations are often contradictory.

One report[1] from the Bureau of Dental Standards in Australia stated, ". . . can be copper plated with no more effort or equipment than is required to electroplate an impression in modelling compound or wax." Rosenstiel[2] also speaks of copper plating Thiokol in the same manner as "ordinary composition" impressions, and he found that a test bridge made on the copper-plated replica did fit the original steel die. Pearson[3] indicated that Thiokol could be copper plated without danger of distortion, even after storing the impression for 8 days. On the other hand, although Skinner and Cooper[4] were able to produce a smooth deposit of copper on Thiokol impressions, they did observe a slight distortion. Beagrie[5] employed colloidal graphite as the metalizing agent but did not feel the results were encouraging. Silver[6] described a silver-plating technique for Thiokol, using as the metalizer pure silver in a colloidal suspension, with electroforming being carried out in a silver cyanide solution. Blank[7] also describes a silver-plating procedure with Thiokols while Willmott[8] advocates a copper or stone die.

Skinner,** referring to silicone, states, "In contrast to impressions made with rubber materials the impression with Sili-Gel can be electroplated to produce a fairly accurate die." However, another publication[9] recommends silver plating of Thiokol and copper plating of silicone.

It is thus apparent that further research is needed before the status of plating techniques for these materials can be established. Therefore, the purpose of this investigation was to evaluate several methods of metalizing and plating Thiokol and silicone impressions.

PROCEDURE

Two popular brands of Thiokol and four silicone impression materials purchased on the open market were used (Table I). It must be recognized that the

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**Skinner, E. W.: Personal communication, Oct. 2, 1956.

formulas of these products may be altered considerably following the submission of this article; however, the data are valid for the batches that were tested. Silver deposition was carried out in the basic silver cyanide solution purchased from the Kerr Company; the copper-plating bath was copper sulfate as described by Phillips and Dettman.[10]

TABLE I. MATERIALS USED

BRAND	BATCH NUMBERS	MANUFACTURER
Elasticon	752 PP 323 PP 415 752 PP 328 PP 416 752 PP 329 PP 416 763 PP 527 PP 631 782 PP 812 PP 690 783 PP 819 PP 854	Kerr Manufacturing Co. Detroit, Mich.
Lastic 55	0427	A. Kettenbach Wissenback—Dillkreis/ Hessen
R and R Silicone		The Ransom & Randolph Co. Toledo, Ohio
Sili-Gel	745 748 749 (Base 1112) (liquid 131)	Dental Perfection Co. Glendale, Calif.
Permlastic	748 PP 828 PP 839 773 PP 542 PP 548	Kerr Manufacturing Co. Detroit, Mich.
Coe-Flex	P W 5 R 18 B 3 P 2	Coe Laboratories, Inc. Chicago, Ill.

The metalizing agents included silver powder, bronzing powder, colloidal graphite (Aqua-dag), a mixture of colloidal graphite and silver powder (Flash-Plate), and a precipitated silver film. Finely powdered metal or alloy is easily applied to the silicone and Thiokol impression materials, merely by brushing on with a soft brush and blowing off the excess. A continuous conductive film results, held to the impression either by the slight tackiness of the surface or by an electrical charge. The colloidal graphite and the colloidal graphite plus silver powder were painted on the impression, also, but these were dispersed in water rather than used as a dry powder. The silver film was precipitated onto the impressions' surface from a silver nitrate solution, using a reducing agent.[10] The various metalizing agents serve not only to form a conductive coating on the impression but also to complete the circuit between the impression and the metal shell or wire connected to the negative D.C. terminal.

Two types of impressions were plated. One was a band, tube, or shell impression of the die. Heavy rigid copper caps, with 13 and 16 mm. inside diameters, were used for these tube impressions. The dies used included the standard MOD and

full crown steel dies, a jacket preparation on a lower Dentoform incisor, and MOD and MOD-BL preparations on a Dentoform upper and lower molar, respectively. All preparations had either shoulders or boxes. The second group of tests were made from quadrant type impressions made of two series of preparations, using specially prepared acrylic resin trays to hold the impression material. One of these series consisted of three MOD and one full crown preparation in porcelain teeth. The second series involved two bicuspids and two molars.

Manufacturers' directions were carefully followed in proportioning and mixing the impression materials. The appropriate adhesive was used in the trays and copper shells. A syringe was used in all instances except for Lastic 55. Impressions were allowed to cure ten minutes from the start of mix. A warm, moist humidifier held at 99°±2° F. was used for storing the impressions during curing. The dies were also stored in this compartment before making the impression. The impression was prepared for plating as soon as possible after removal from the die. The tube impressions were plated at 100 Ma. for 6 to 18 hours in the acid copper sulfate bath, while only 10 to 50 Ma. of current were used for silver plating. The tray impressions were plated at 400 Ma. in the copper bath and 100 Ma. in the silver bath.

The plated dies were washed and poured in stone.* Ease or difficulty in separation of the die was noted. The accuracy of the resulting die was measured by use of master control castings fabricated on the original dies. This same technique has been used satisfactorily in previous studies.[11-13] The snugly fitting castings seated fully on the original under a load of slightly less than one pound. A one pound load was used to seat the casting on the plated die, and the distance by which the casting failed to seat was measured with a micrometer microscope.

RESULTS

General Observations Upon Separation of Die.—

Silver-plated Thiokol impressions: When silver powder is used as the metalizing agent, separation is clean. A bright silver die results unless the current density has been too great during the early stages of plating. The surface of the die is smooth, and no gross distortion is visible except for a slight convexity at the pulpal floor (Fig. 1, *b*). The use of a precipitated silver film produces a grayish looking die but with less convexity at the pulpal floor.

Copper-plated Thiokol impressions: Metalizing with silver powder produces no special problems. However, deep areas do not copper plate as well as they silver plate. The pulpal floor is convex and may also be wrinkled (Fig. 2). When a precipitated film is used, separation is difficult, and the color is grayish with areas of copper showing through. However, the pulpal floor is less convex and no wrinkling is observed.

With bronzing powder, a clean separation of the die results. The pulpal floor is convex, and wrinkling may or may not be present. When Binding Fluid† was used preceding the silver powder application, the wrinkling was more severe. Use

*Vel-Mix, Kerr Co., Detroit, Mich.
†Hanau Engineering Co., Buffalo, N. Y.

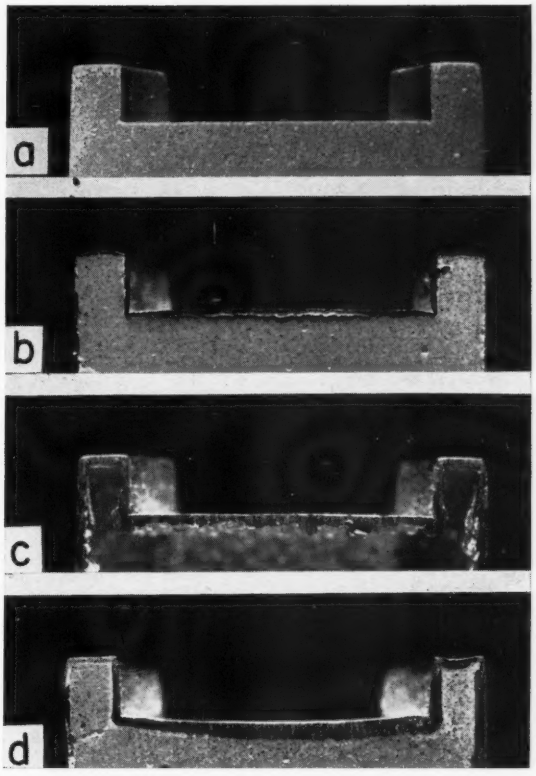

Fig. 1.—Distortion on the pulpal floor when a silicone or Thiokol impression is plated. *a*, Hydrocal die. *b*, Silver die from Thiokol. The maximum convexity observed. *c*, Silver die from Thiokol showing the average degree of convexity. *d*, Silver- (or copper-) plated Sili-Gel showing typical concavity.

Fig. 2.—The pulpal floor of a copper-plated Thiokol die.

of Aqua-dag and Flash-Plate permits easy separation of the diet. The occlusal is convex and may be wrinkled. The detail is not as sharp as when the powders or precipitated silver are used.

Silver-plated silicone impressions (R and R and Kerr): Separation is easy when silver powder is used to metalize. However, the die often has small nodules which do not appear as readily on stone dies poured in the same material (Fig. 3). The pulpal floor is convex.

TABLE II. ACCURACY OF SEATING

METALIZING AGENT	SILVER DIES		COPPER DIES	
	COEFLEX OR PERMLASTIC	ELASTICON OR R AND R SILICONE	COEFLEX OR PERMLASTIC	ELASTICON OR R AND R SILICONE
Ag powder	0.06 mm.*	2.00 mm.*	0.90 mm.*	1.22 mm.*
Ag powder and binding fluid	nodules prevent seating		0.40 mm.	
Precipitated silver	0.22 mm.	1.96 mm.	0.00 mm.†	1.33 mm.
Bronzing powder			0.06 mm.	0.90 mm.
Aqua-dag			0.33 mm.	
Flash-Plate			0.08 mm.	1.11 mm.

*Represents the distance by which a casting which seated fully on the original steel MOD die fails to seat on the electroformed die when pressed to place under a load of one pound.
†See text.

Copper-plated silicone (R and R and Kerr): When silver powder is used for metalizing, separation of the impression and the die is difficult. The impression material tears and pieces of it stick to the die (Fig. 4). The dies can, however, be cleaned by soaking in chloroform, followed by mechanical removal of the impression material. The surface of the die is a dull silver color and studded with small nodules. The pulpal floor is convex. The use of bronzing powder permits easier separation of the die but nodules are still present.

Sili-Gel: Only silver powder and precipitated silver were used to metalize Sili-Gel impressions. When precipitated silver was used, the dies were gray colored and pitted. With the silver powder, the dies were a dull, silver color with small nodules covering the pulpal floor. Some surfaces of the metal dies were concave when they should have been flat (Figs. 1, *d* and 5). Separation of either the silver or copper dies presented no problem.

Lastic 55: Silver powder metalizing was satisfactory for both silver and copper plating. No separating difficulty was encountered, and the pulpal floor was fairly flat.

Accuracy of the Metal Dies.—

When silver plating, preliminary studies showed no advantage in the use of bronzing powder, Aqua-dag, or Flash-Plate over the silver powder for metalizing. Thus, since Aqua-dag and Flash-Plate were more difficult to use and produced somewhat inferior surface detail, only silver powder and precipitated silver were used to metalize prior to silver plating. The data for the various combinations used may be seen in Table II, the values being the mean for 4 to 6 individual dies.

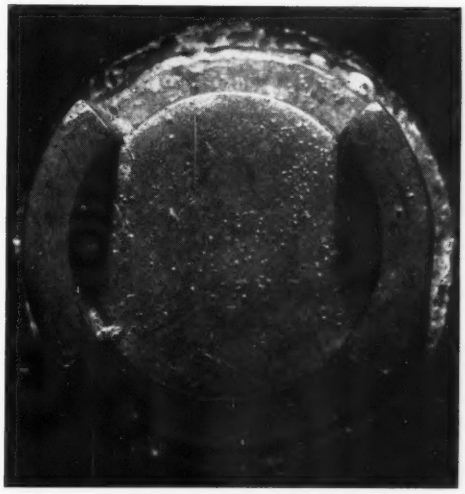

Fig. 3.—The pulpal floor of a silver- (or copper-) plated Elasticon die.

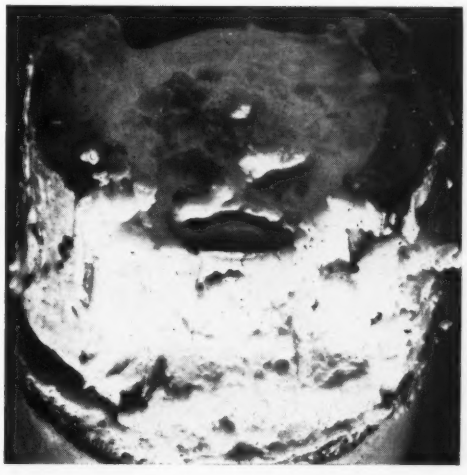

Fig. 4.—A copper electroformed die with adherent silicone.

Although the data would indicate that the most accurate die could be made by copper plating, a Thiokol impression metalized with precipitated silver, complete coverage with copper required re-metalizing the deepest portions of the im-

pression with silver powder. The procedure which routinely produced the most accurate results with the greatest ease was silver plating Thiokol dies which had been metalized with powdered silver. Bronzing powder and copper plating seemed to be equally satisfactory (Fig. 6) except for occasional wrinkling of the pulpal floor. Neither copper nor silver plating of Elasticon or R and R silicone could be accomplished without resulting in marked deformation of the die (Fig. 6).

Fig. 5.—The pulpal floor of a silver- (or copper-) plated Sili-Gel die showing concavity and nodules.

Sili-Gel can be electroformed with no apparent distortion when tested with the master casting. However, this test may be somewhat misleading, since the concavity (Fig. 5) of the pulpal floor would make the die unsatisfactory for typical indirect procedures.

TABLE III. ACCURACY OF DIES

	STONE DIE	AG PLATED DIE (AG POWDER METALIZING)
Elasticon	0.06 ± 0.02 mm.	0.3 ± 0.1 mm.
Coe-Flex	0.00	0.02 ± 0.02 mm.

A full cast crown used as a master casting. Values are the mean for four dies.

Using the four Dentoform teeth (Fig. 7), the results are much the same as when the four porcelain teeth were used (Fig. 8). With a Coe-Flex impression, the castings seat on the metalized die as well as on a Duroc die poured before plating of the impression. When Elasticon is the impression material, the control castings will seat properly on Duroc dies poured immediately, but none of the castings will seat on a silver- or copper-plated die.

Table III summarizes the results obtained when the four porcelain teeth were used, listing numerical values for the full crown only. The data in this table support previous results. The initial accuracy of the Thiokol impression is slightly better than that of the Elasticon and R and R silicone, and distortion of the silicone during storage or during plating is considerably greater than is the distortion of the Thiokol under the same conditions.

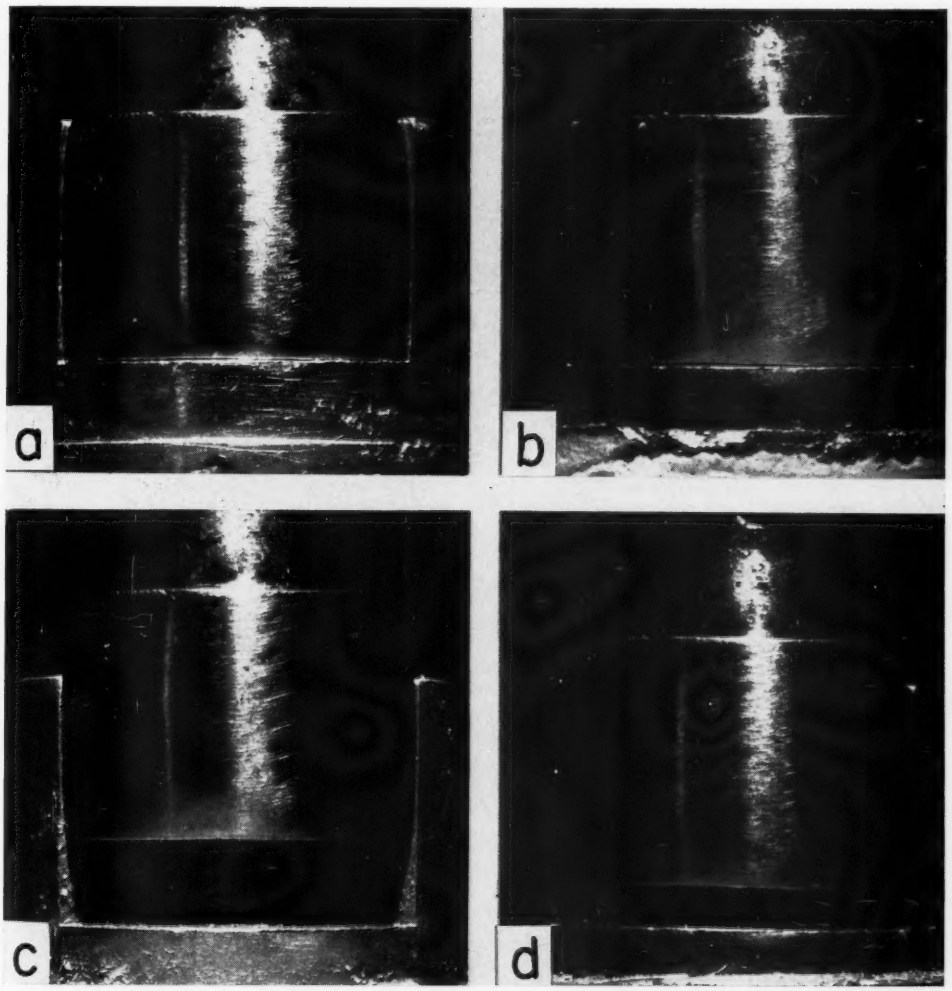

Fig. 6.—Electroformed dies from Thiokol and silicone impressions. *a*, Thiokol—silver. *b*, Thiokol—copper. *c*, Silicone—silver. *d*, Silicone—copper.

DISCUSSION

The results of this study would indicate that neither copper- nor silver-plating is entirely satisfactory for silicone impressions. None of the plated dies are equal

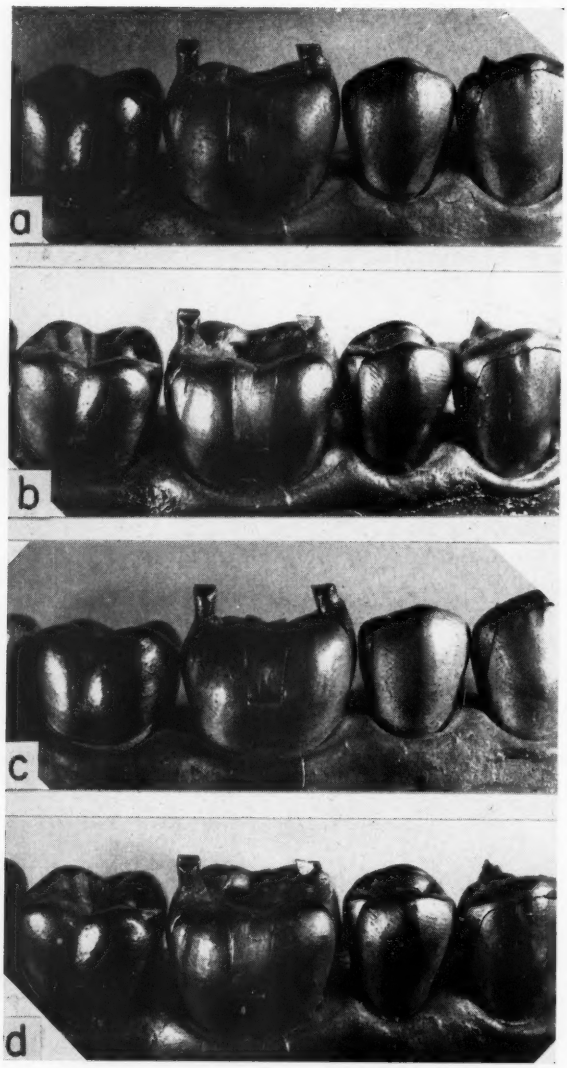

Fig. 7.—Electroformed dies from Thiokol and silicone. *a*, Thiokol plated with silver. *b*, Thiokol plated with copper. *c*, Silicone plated with silver. *d*, Silicone plated with copper.

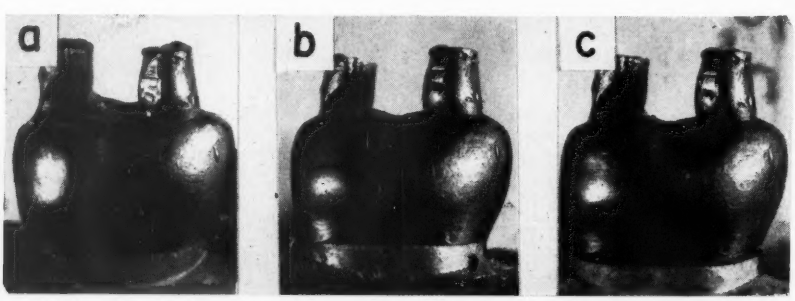

Fig. 8.—The fit of the master casting on *a*, the porcelain die. *b*, Silver-plated die made in a Permlastic impression *c*, Silver-plated die made in an Elasticon impression.

to stone dies poured immediately, either from the standpoint of dimensional change or surface irregularities. Distortion was comparable to a stone die which had been poured in an impression stored 6 to 24 hours. The copper-plated dies were more accurate than the silver-plated ones, but the difficulty of separating the impression was greater.

The convexity of the pulpal floor on all the metal dies, except those from Sili-Gel and Lastic 55, was a disturbing factor and a condition which had not been previously detected in stone dies. However, re-examination of a group of stone dies showed that a convexity of the pulpal floor was present in many of the dies poured from Thiokol impressions which had been stored 8 hours or longer. The condition was not as noticeable on the stone dies as on the electroformed dies. The convexity of the die did seem to be related to the surface condition of the impression. The concavity on some surfaces of the electroformed dies from Sili-Gel, especially on the pulpal floor, did not appear to be due to the impression's surface and was not found in stone dies. Both the concavity in certain areas of the electroformed die surface and the pitting observed on hydrocal die surfaces are probably related to the evolution of gas from the Sili-Gel.

The wrinkled surfaces present occasionally on copper-plated Thiokol dies may be associated with the swelling of the Thiokol and its confinement within the copper shell during the plating process in the acid copper sulfate bath. The wrinkles appear on both the impression and die surface following separation of the impression and copper die.

SUMMARY

Copper and silver electroformed dies were made from Thiokol and silicone impressions of steel dies and two series of prepared Dentoform-type teeth. Observations of the dimensional accuracy and surface characteristics of the resulting dies were made. Critical evaluation of the metal dies revealed that none reproduced the original quite as well as the stone dies. Silver plating of Thiokol was found to be the most reliable procedure producing fairly accurate and clinically acceptable metal dies. The results did indicate that copper dies from silicone impressions were more accurate than were silver dies from silicone impressions, but neither compared favorably with electroformed dies made from Thiokol impressions.

CONCLUSIONS

1. Both Thiokol and silicone impressions can be plated, either in a basic silver cyanide or in an acid copper sulfate bath.
2. Throwing power and reliability of the basic silver bath was markedly greater than for the acid copper bath used.
3. The very finely powdered metals or alloys can produce more accurate surface detail than a brushed-on colloidal graphite film.
4. Routinely, the most accurate electroformed die, with the best surface detail, was obtained when Thiokol was metalized with silver powder and plated in the basic silver cyanide bath.

5. The copper electroformed die shows less distortion than the silver die when a silicone impression is plated, but it is doubtful whether electroplating of a silicone, at least with the techniques studied, is to be recommended because of distortion of the impression during plating.

6. Silver powder is recommended for metalizing prior to silver plating, and bronzing or copper powder metalizing prior to copper plating.

7. When a metal die is desired, a silver-plated die from a Thiokol impression is recommended.

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USES OF AUTOPOLYMERIZING ACRYLIC RESINS IN FIXED PARTIAL PROSTHESIS

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A REVOLUTIONARY ADJUNCT HAS been developed in dental practice since 1948. The introduction of the autopolymerizing acrylic resins has accounted for the saving of untold chairside hours and has provided patients with additional esthetic and comfort benefits prior to the completion of the treatment.

PROTECTION OF TEETH BETWEEN VISITS

One of the dental profession's biggest problems has been the placing and replacing of temporary protective devices over teeth prepared for crowns so the patient would be comfortable between visits. These coverings (which are still used) are aluminum shells and celluloid or plastic crown forms filled with sedative cements or silicate cements. The time wasted in replacing these temporary restorations during each patient's visit, the aggravation caused by their appearance, and the loss between visits can be eliminated completely by the use of acrylic resins which cure in the mouth.

One or more teeth may be prepared for full coverage at one time, and may be fully protected with a temporary crown that is shaped like and looks like the natural tooth. Missing teeth may be replaced temporarily by the judicious use of plastics which cure in the mouth. All of this may be done in one visit and need be done only one time, since the temporary crown, bridge, or splint may be used over and over again until the final restorations are cemented in place.

TECHNIQUE

The technique to be described may be used for temporary individual crowns, splints for multiple abutments, or fixed partial dentures. The construction of a temporary fixed partial denture with one or more teeth missing may be accomplished by the use of a study cast, the mouth, or by a combination of both.

(1) The missing tooth may be waxed-up on the study cast and an alginate impression made of the restoration on the study cast. (2) The teeth may be pre-

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pared on the study cast, and the temporary restoration may be made on it. (3) An alginate impression may be made of the jaw in which the tooth is to be replaced and the edentulous area cut out to simulate a tooth. This prepares the impression for the next step. (4) A softened piece of wax may be placed into the edentulous space in the mouth and roughly shaped like a tooth, then an alginate impression can be made.

After an alginate impression is made under any of the above conditions, the abutments are prepared. The tissues and teeth are then lubricated with petroleum jelly to facilitate the removal of the setting acrylic resin and to protect the mouth from the irritation caused by the material. A thin mix of self-curing acrylic resin is made and flowed into the abutment and edentulous space of the alginate impression. When the resin has reached a tacky consistency, the alginate impression is placed in the mouth and held in place until it has a rubbery consistency. The alginate impression is removed, and if the temporary bridge does not come off in the alginate impression, it is teased off the teeth. The resin should be in a rubbery state without the formation of heat. The flash which is present is trimmed with curved shears. The trimmed rubbery resin is placed on the prepared teeth, and the patient is directed to close in centric occlusion in order to minimize the occlusal adjustments after the resin is set. As the resin begins to get warm, it is carefully removed from the teeth and placed in cold water until it is set. This helps the resin retain its moisture while the exothermic reaction occurs and keeps the abutment teeth from becoming overheated. Also, this helps to prevent the shrinkage which occurs normally when large amounts of monomer are used.

The abutments and pontic are shaped and polished. Also, the embrasures are opened. The margins are trimmed, and the occlusion is rechecked. The temporary bridge is cemented with any anodyne mixture other than plain zinc oxide and eugenol. Eugenol softens the acrylic resin, so it must not be used.[1]

IMMEDIATE RESTORATIONS

Temporary acrylic resin restorations may be used also to prevent embarrassment of patients who must have teeth (especially anteriors) extracted. In this technique, an alginate impression is made while all the teeth are still present in the mouth. The teeth to be used as abutments are prepared, the extractions are performed, and a temporary fixed partial denture is made as previously described. The pontics are trimmed so that the resin will not extend into the sockets and thus delay healing. After the resorption of the alveolar ridge has occurred, new acrylic resin may be added to re-establish the ridge lap contact with the tissue. In finishing this temporary restoration, care must be exercised to smooth and highly polish the ridge lap and to eliminate all displacement of the soft tissues. If the teeth to be retained are broken down, they can be rebuilt with wax prior to making the impression. This restores more normal tooth morphology.

(A heat-cured acrylic resin fixed partial denture can be made when detailed esthetics or finished margins are required. An alginate impression of the entire dental arch including the prepared teeth is made as well as an impression of the opposing dental arch and an interocclusal wax record.)

TRANSFERRING JAW RELATIONS

A simple method of transferring jaw relation records from the mouth to the articulator becomes feasible with the use of the self-curing acrylic resins. Transfer copings may be made from this material. Dies of the prepared teeth are lubricated and painted with a viscous mix of self-curing resin which is shaped into the desired contour. When the resin has set, the margins of the copings are trimmed to the finish line and finally shaped. The copings are placed in the mouth, and it is a simple procedure to grind them into the desired centric occlusion.* Multiple copings may be made when a complete mouth rehabilitation is undertaken. They are contoured to simulate the natural dentition and ground into the desired vertical dimension and centric position. A dense acrylic resin must be used so as to minimize distortion and dimensional change of the copings. Complete arch plaster impressions are made of both dental arches with the copings in place and poured. The casts may be occluded easily by hand and mounted on the articulator with the desired vertical dimension unchanged.

Rubber base or elastic impressions of the abutment teeth can be made. When this material is used, acrylic resin copings are made on the preparations on the stone master cast. The copings are placed in the mouth and, by means of selective grinding, are brought into the occlusion at the desired vertical dimension. A thin mixture of self-curing acrylic resin is placed on the occlusal surfaces of the copings. The patient is instructed to close into centric occlusion, thus luting the opposing copings together. When the resin has cured, the attached copings are removed from the mouth and the preparations on the stone casts are fitted into them. The casts are then mounted by means of this registration.**

ESTABLISHING VERTICAL DIMENSION

Temporary splints and fixed partial dentures may also be constructed to reestablish the vertical dimension of occlusion in a collapsed dentition. Self-curing acrylic resin may be used as an overlay on existing partial dentures to build up the occlusion. Often, these same restorations are made to maintain the vertical dimension, but care must be exercised to leave enough strategically located unprepared teeth so that they may act as occlusal stops until all of the temporary restorations are made.

When unit-built individual anterior porcelain jacket crowns and framework are made to replace missing teeth, or to splint teeth together, the thimble framework may be inserted temporarily before the porcelain crowns are finally cemented to place. Temporary acrylic resin crowns joined together may be readied so that the patient need not be embarrassed while the framework is worn temporarily. Self-curing acrylic resin may be used also when a cemented porcelain jacket crown fractures. An adequate restoration may be made in a few minutes to serve as a temporary crown while a new porcelain crown is being constructed.

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*David H. Coelho: Personal communication.
**Edward G. Kaufman: Personal communication.

When heat-cured acrylic resin facings discolor or break out of the gold backing, a self-curing plastic may be used for making a new facing. A new tooth may also be made rapidly when a tube porcelain pontic fractures, should such an accident occur.

SUMMARY

Self-curing acrylic resins have many possible uses for making temporary restorations. Many of these have been discussed and the techniques for making these temporary restorations have been described. There are many different variations for these procedures which will produce adequate results if they are properly controlled.

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TECHNIQUES FOR THE USE OF ULTRA HIGH ROTATIONAL SPEEDS USING BELT-DRIVEN AND TURBINE-DRIVEN EQUIPMENT

VI. A Progress Report

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THE ADVENT OF A handpiece, in 1955, which could be used for preparing teeth for all types of cavities and restorative procedures at speeds above 60,000 r.p.m. signaled a new and much better concept of dental care.[1] It also demanded a different technique in the use of cutting instruments. A dentist starting to use ultra high speeds is impressed by the fact that although he needs very few carbide burs and diamond stones, he is at a loss to know which instrument will be best for the procedure at hand. This article will suggest the cutting tool which can complete the operation with the most efficiency. It will also discuss other problems which arise with the use of the very high rotational speeds.

The fact that the patient is saved the annoyance and discomfort of vibration (speeds in excess of 60,000 r.p.m. pass the vibration perception point of the human brain) as well as having the tooth cut much faster made it much easier for him.

ADVANTAGES OF HIGH ROTATIONAL SPEEDS

For the dentist, many advantages were discovered. (1) Because the patient was more amicable to dental care, due to lack of vibration, the dentist found that he also was more relaxed; (2) the instrument, because of the lack of force necessary for cutting which is due to its low torque, made operative procedures much safer; (3) more income could be realized by the dentist because his work output was increased; (4) cutting tools lasted much longer because the cutting edges touched the tooth very lightly, and, as much fewer types of cutting tools are needed, this expense was decreased; (5) many dentists whose practices were limited primarily to operative procedures found that they had more time and could attempt some of the more difficult reconstruction cases, and full coverage preparations also were accomplished with much greater ease; (6) the general practitioner also found that ultra high speeds greatly facilitated the removal of impacted and ankylosed teeth, because bone and tooth structure were so easily removed; (7) because teeth were

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traumatized less due to the light touch and the cool cutting tool, less postoperative complications resulted; this made more time available for increased remunerative procedures and better patient acceptance.

Dentistry today has a multiplicity of ultra high speed instruments at its command. They may be divided into three classifications:

Type I, *Gear-driven Contra-angle Handpieces*

Midwest Hy-Drive	(up to 125,000 r.p.m.)
Straight handpiece with trans-speed powers the contra-angle	(oil injection)

Type II, *Belt-driven Contra-angle Handpieces*

Page Chayes handpieces	(up to 200,000 r.p.m.)
Kerr super speed handpieces	(up to 150,000 r.p.m.)
Globe	(up to 200,000 r.p.m.)

Type III, *Turbine-driven Air Contra-angle Handpieces*

Borden (Ritter, S.S. White)	(up to 300,000 r.p.m.)
Weber	(up to 300,000 r.p.m.)
Densco	(up to 300,000 r.p.m.)
Midwest—Air Drive	(up to 300,000 r.p.m.)

All of these handpieces, when used at speeds in the supersonic range (above 60,000 r.p.m.), cut tooth structure with various degrees of efficiency. I have used all types of equipment routinely for all types of dental procedures. Some preparations were made with all three types of instruments used on the same tooth. For maximum efficiency, each of two or three ultra high speed instruments mounted at the chair can have a different cutting tool mounted in it. These three cutting tools can be selected to do the entire operation. Then, by choosing the proper handpiece, the indicated cutting tool can be used without stopping for a bur change. This arrangement saves the time wasted by changing cutting tools (Fig. 1). One ideal arrangement has the Page Chayes handpiece mounted on an Emesco auxiliary motor, a Midwest Hy-Drive handpiece mounted on the Model H Ritter Unit, and a Borden Air-Turbine mounted on the bracket table arm. The Hy-Drive can be changed readily to a straight handpiece, if necessary.

As some procedures cannot be done with ultra high speeds, it is necessary to have the regular gear-driven slow handpiece available. Dental prophylaxes, straight handpiece procedures, polishing of amalgam fillings and inlays, trimming dentures, and powering amalgam vibrators, are the main uses for the slow gear-driven handpiece.

The use of Type II belt-driven contra-angle handpieces is facilitated by dual engine setups. This saves the time consumed by changing from contra-angle to straight handpieces at the wrist joint.

Turbines are powered by the compressor air line which must be adequate for the large volume of air demanded by these instruments.

In my experience, the early model turbines have had the following undesirable features: First, the lack of torque made it difficult to execute some procedures due to a lack of tactile sense. Second, the lack of variable foot control of the turbines

made their use more time-consuming since it was necessary to vary the speed control valve by hand. Third, the oil mist generated from most turbines caused the mirror to fog up and contaminated the preparations. It is not desirable for the patient and the dentist to breath air contaminated by this oil. Preparations made in the presence of an oil mist should be wiped carefully with a solvent, such as carbon tetrachloride, to avoid contamination of the filling. A high velocity evacuant, such as the Vacudent apparatus, helps to suck away some of this oil mist at the region about the tooth.

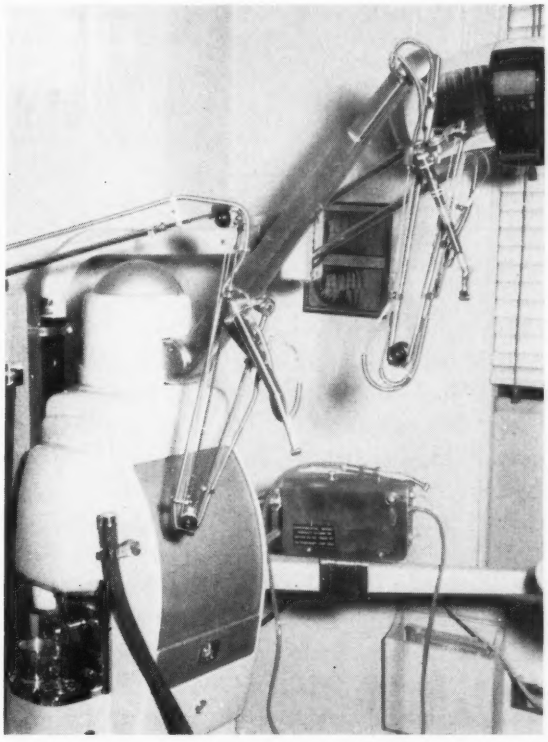


Fig. 1.—Triple ultra high-speed arrangement. A Page Chayes handpiece is mounted on an Emesco high-speed auxiliary engine, a Midwest oil injected Hy-Drive handpiece on the Ritter Model H unit and an experimental Borden Airotor on the bracket table arm.

A water spray coolant is mandatory for all ultra high-speed procedures. Many warnings have been given by researchers who have proved that extreme and sometimes irreparable pulp damage is caused by lack of water spray coolants. It is imperative for the coolant to be on the tooth and cutting tool at all times. If cut white tooth structure is observed, not enough coolant has reached the area of the cut. It is desirable to have the coolant openings around the top of the bur tube so that the tongue or cheek do not deflect the coolant. The smell of burned tooth structure may be noticed at times when using the ultra high speeds. This is due usually to particles of the cut structure being blown out of the mouth. A heavier coolant spray should be used.

To develop the very light touch required for using the ultra high speeds, it is helpful to practice by cutting extracted teeth on a postal scale. Some dentists experience great difficulty in acquiring this touch, but others have no trouble at all.

The question about how much torque is desirable for the ultra high speeds is important. Torque has been defined as "that which produces or tends to produce rotation." To the dentist, this means at what finger pressure does the cutting tool stall or stop. Quick stalling or low torque is desirable for safety, but there is a point of diminishing return. Most turbines, particularly with low air pressures, stall much too quickly. The belt-driven contra-angles have more torque than the turbines, but not so much that they slip and twist out of control.

OTHER USES

The ultra high speeds can be used by periodontists for occlusal equilibration and some gingival resections. Bone contouring is also very easy to do as control is always evident.

The oral surgeon can trim and contour bone, as well as section teeth, with no temporomandibular joint trauma.

The orthodontist who does occlusal equilibration finds the ultra high speeds a valuable asset.

In pedodontics, the ultra high speeds have become invaluable. Children who have been initiated to dental service with the ultra high speeds have found it difficult to accept the below sonic level rotational speeds.

The dentist who makes inlay and full coverage restorations finds that occlusal adjustments can be made readily in the mouth. This is a great time saver in that much time is wasted in removing and replacing these restorations when fitting them to the occlusion. Acrylic resin fillings can be trimmed with ease by this means. Silicate fillings should not be trimmed at the initial set because of the action of the coolant.

Some ultra high-speed instruments still lack the full compliment of cutting tools, but all manufacturers are making many types of cutting tools available. With the friction grip type, such as found in the Page Chayes and the Airotor handpieces, the shanks can be shortened by the dentist for use in children's mouths and adults with limited opening ability. Friction grip instruments have a tendency to creep out of the rubber or plastic chucks. Lubrication should be kept to a minimum. The chuck and cutting tools must be checked for eccentricities as cusps of teeth can be chipped and damaged by eccentric instruments.

OBJECTIONS TO ULTRA HIGH-SPEED INSTRUMENTS

Some dentists have been hesitant to use the ultra high speeds, because of the following reasons: (1) The noise seems to annoy them, and they fear the patient would not accept it. (2) The patient would get the idea that the dentist was in too much of a hurry. (3) Those men who have been using the medium high speeds (up to 45,000 r.p.m.) feel that there is no great saving in time. (4) Equipment now available may be obsolete in a short time. (5) The possibility of damage to tooth structure, due to rebound phenomena.[3] (6) Difficulty of working with a coolant due to mirror fog.

These objections may be overcome on the basis of the following considerations:

1. It is true that all belt-, gear-, and turbine-driven equipment at ultra high speeds is noisy.[2] Most patients who complain of the noise (they are extremely few) can be convinced of the advantage of ultra high speed if a demonstration is given on their own teeth by cutting first with a low and then ultra high-speed instrument.

2. After questioning many patients about the fact that the operation was done too quickly, almost everyone replied that the job could not be done too soon.

3. It is true that a disk or large stone turning at 20,000 r.p.m. will cut with a peripheral speed which is equal to the speed of a small stone in a supersonic instrument, but some vibration is still quite evident. Patients appreciate a lack of vibration. The fact that smaller cutting tools are used is a safety factor, as well as lowering the vibration.

4. It is true that other means of cutting teeth are being developed, particularly in the electronic field. A handpiece that develops over 1,000,000 r.p.m. has been reported. Whether these new instruments will supplant all others is difficult to predict at this time. It should be remembered that the purchase price of a belt-driven contra-angle handpiece will be returned many times over after several months' use. The cost of most turbines is somewhat more, but all ultra high equipment will more than pay for itself in income return, as well as in patient acceptance. A complete range of speeds is not essential for efficiency. Some researchers* feel that ultra high speed should be used only for bulk tooth reduction and that medium speeds (40,000 r.p.m.) should be used for finishing and internal preparations. I feel that all procedures accomplished with medium speeds can be performed with ultra high speeds, but it is a matter of individual preference.

5. Many investigators have proved that when a proper coolant is used, there is less damage to the pulp and other structures.[4,5] To supplement this and to refute other reports of damage, the number of teeth being prepared daily (over 40,000 of these instruments are in use) with no reports of damage is an overwhelming clinical endorsement.

6. The problem of mirror fogging as yet has not been solved. Dipping the mirror in a warm detergent or germicidal solution helps. Several devices, such as the Roto-Mirror and air mirror are available and offer some aid.

The dentist considering ultra high speeds should exercise the quality of empathy, appreciate the patient's viewpoint, and have his own teeth prepared with low, medium, and ultra high speeds, and then select the speed most agreeable.

SPEED OF OPERATION

Speed in preparations depends on many factors: (1) The ability of the dentist. (2) The temperament of the patient; some are easy and some are difficult to work on. (3) The temperament of the dentist. Some men prefer to let the ultra high-speed instrument make tooth preparations easier for them and the patient and are not interested in cutting down the preparation time. Some dentists find it impossible to be at ease with ultra high speeds. It is not a question of being extremely heavy-handed, it is a matter of personal confidence in the method one is using. If,

*Rex Ingraham: Personal communication.

after several months' trial, confidence cannot be achieved with a belt-driven contra-angle or turbine, it is suggested that lower speeds be used and that ultra high speeds be used as an auxiliary to remove amalgam and cut through gold restorations. (4) Accessibility is an important factor. It is extremely difficult to get sufficient visibility for working on some upper teeth due to mirror fogging and limited mouth opening. (5) Some type of rapid evacuant apparatus is desirable as mouths tend to load up with coolant fluids quickly. (6) The condition of the equipment is very important. Some older unit engines do not develop sufficient speed, due to too small pulleys, voltage changes, clogged idler pulleys, tight engine belts, and numerous other causes. If the equipment is not cutting at peak efficiency, a step-by-step inspection is necessary.

The use of ultra high speeds can become a monster if it is not controlled. Some dentists complain that they do so many preparations that they do not allow enough time to insert the fillings properly. It is necessary for each dentist to carefully appraise what he wants to accomplish and let the instrument make more leisure time for him, and to do better dentistry, rather than to try to double his income in a short time.

CHOICE OF EQUIPMENT

It is difficult to say what equipment will be most compatible for the average dentist, as all ultra high-speed handpieces perform with more ease and efficiency

TABLE I. INSTRUMENTS USED FOR MAKING CAVITY PREPARATIONS

TYPE OF PREPARATION	INSTRUMENTS	
	CARBIDE	DIAMOND
Class I, II, and MOD (Fig. 2)		
Initial opening through enamel	557*, 2**, 701	H. C. 139, 8B Densco
Outline form	557*, **, 701	H. C. 139
Retention form	557*, **, 701	H. C. 139
Removal of decay	2, 4*, **, 6	None
Finishing	None	1½ MJ*, **, 4 MJ
Class III (Fig. 3)		
Initial opening through enamel	1*, 2**, 557, 701	None
Outline form	557*, 2**, 701	H. C. 139
Retention form	557*, **, 701, 35	H. C. 139
Removal of decay	2*, **, 4	None
Finishing	None	1½ MJ*, **, 4 MJ
Class V (Fig. 4)		
Initial opening through enamel	557*, 2, **, 701	H. C. 139, 8B** Densco
Outline form	557*, **, 35	H. C. 139
Retention form	557*, **, 35	H. C. 139
Removal of decay	2, 4*, **	None
Finishing	None	1½ MJ*, **, 4 MJ

H. C.: Hollow Core Diamond-Rode.
MJ: Meigs-Jones Set by Rode.
*Most universal for belt-driven equipment.
**Most universal for turbines.

than those operating at speeds below 60,000 r.p.m. Some dentists may find that the turbines require a touch too light for them to feel comfortable, and they will like the feel of the additional torque offered by the Page Chayes type of contra-angle handpiece. Some will find a combination of the gear-driven handpiece coupled with the turbines or belt drive the most suitable.

In my hands, the ultra high-speed instrument which has been most versatile and trouble-free was the Page Chayes belt-driven contra-angle handpiece with the Borden Airotor, the Densco, Aero-Turbex, and the Weber close seconds. The Midwest Hy-Drive was an extremely acceptable third. Sufficient testing of the Midwest Air Drive was not possible.

Fig. 2.

Fig. 3.

Fig. 2.—Entire Class II preparations are made with a No. 557 bur.
Fig. 3.—A Class III prepared with No. 2 carbide bur.

CUTTING INSTRUMENTS

Some dentists will find that some teeth cut better with carbides than diamonds, and vice-versa. If difficulty is experienced with both, one of three things is at fault. (1) The cutting instruments are not sharp and should be changed. (2) The handpiece is not adjusted properly. (3) The dentist has not acquired the proper "touch." The techniques suggested have made use of a variety of cutting instruments for each operation. The most universal tool for each operation listed in Tables I and II will have an asterisk for belt-driven equipment, and a double asterisk for turbines.

Figs. 2-4 show preparations made with one cutting instrument.

Undercuts in dentine for convenience pits for gold foil and other materials can be placed with a No. 33½* Steel bur-Premier.

Amalgam is readily removed with a No. 6* or No. 557 carbide, No. 2,** No. 4** for turbines.

Gold can be cut first with a wheel type diamond* followed by a No. 4, No. 6, or No. 701 carbide bur, or a No. 1** for turbines.

With belt-driven contra-angle handpieces, 100,000 to 150,000 r.p.m. are used.

With a turbine at 30 to 60 pounds pressure, 200,000 to 300,000 r.p.m. are used.

All cutting instruments last much longer when used at speeds over 100,000 r.p.m. Burs used for cutting gold and amalgam should be set aside and used for this purpose exclusively.

The belt-driven equipment cuts gold faster than the turbines tested, but the turbines performed with a smoother action (Table II).

Figs. 5-10 show slice type inlay preparations made without using disks. Figs. 11-15 show porcelain jacket crown preparations.

When decay has to be removed near a pulp, it is desirable to get maximum visibility by cutting off all water and using air alone at a lower speed. As soft tooth structure only is being cut, very little heat and vibration is observed.

TABLE II. INLAY PREPARATIONS—MO, MOD

TYPE OF PREPARATION	INSTRUMENTS†	
	CARBIDE	DIAMOND
Box type		
Initial opening through enamel	701*, **, 557	H. C. 139
Outline form	701*, **, 557	H. C. 139
Retention form	701*, **, 557	1½ MJ
Removal of decay	2*, **, 4	None
Finishing	None	1½ MJ*, **, 4 MJ
Slice type (Figs. 5-10)		
Initial opening through enamel	171*, **, 701	H. C. 139
Outline form and slice	171*, **	4 MJ
Retention form	171*, **	1½ MJ
Removal of decay	2, **, 4*	None
Finishing	None	4 MJ*, **
¾ crown		
Slice interproximal	171*, **	4 MJ
Bulk enamel removal	701, 171	H. C. 147*, **, 9 MJ
Grooves in dentine	701 or 171*, **, 700 Steel (Premier)	1½ MJ
Removal of decay	2, 4*, **	None
Finishing	None	1½ MJ, **
Full crown shoulderless		
Interproximal	701*, **, 557	4 MJ, 2QP Densco
Bulk enamel removal	701, 557	6 MJ*, **
Champfer	701	6 MJ*, **, 21 Star
Finishing	None	4 MJ*, **
Carborundum stones are sometimes quite effective for bulk tooth removal		
Porcelain jacket preparations (Figs. 11-15)		
Interproximal	171*, **, 701	111 Wheel Rode
Removal bulk enamel	701, 171	6 MJ, **, 212*, 110S Star
Shoulder	701 and Emesco End Cut*, **	4 Rode
Finishing	None	4 MJ*, **

H. C.: Hollow Core Diamond.
MJ: Meigs-Jones Set by Rode.
*Most universal for belt-driven equipment.
**Most universal for turbines.
†No. 171 and 57 are similar to No. 701 and 557, except the blades do not have close-cut serrations and leave a smoother finish but they produce slightly more vibration.

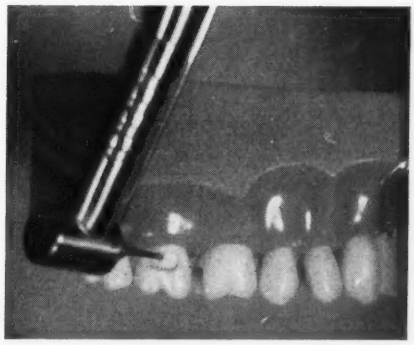
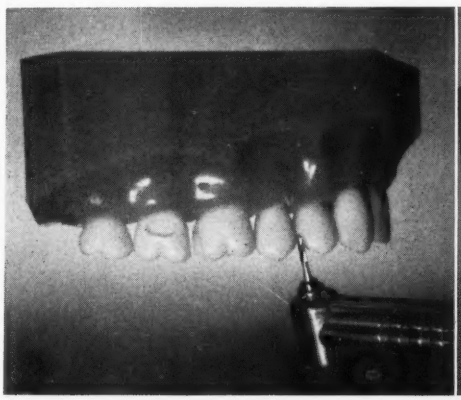


Fig. 4.—A Class V prepared with No. 557 carbide bur.



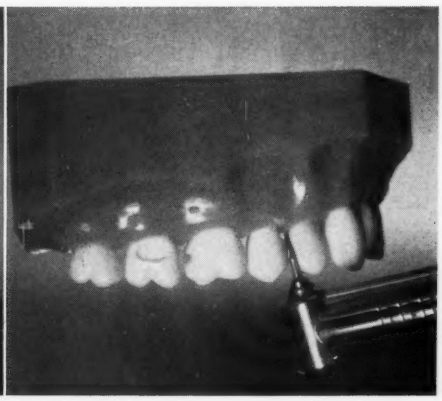
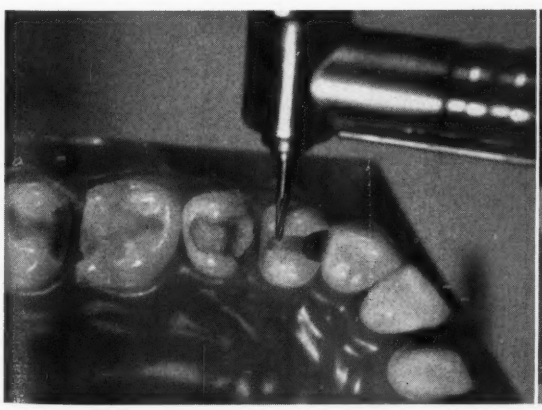


Fig. 5. Fig. 6.

Fig. 5.—A diskless slice preparation. The slice is begun in steps with a No. 171 carbide bur.
Fig. 6.—The second step carries the slice to the gingival area.



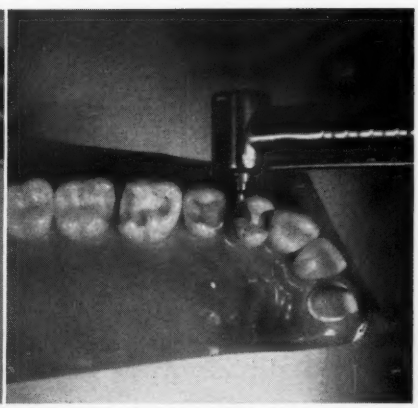


Fig. 7. Fig. 8.

Fig. 7.—An internal box preparation done with a No. 171 carbide bur.
Fig. 8.—The occlusal shaping is done with a Rode No. 9MJ.

When using the larger stones, it is desirable to use copious amounts of water, which means that the volume of the handpiece spray is turned up to maximum. If too large a stone or disk is used, it will start a whipping action and vibrate badly.

All preparations may be perfected with hand instruments, if desired.

Fig. 9.

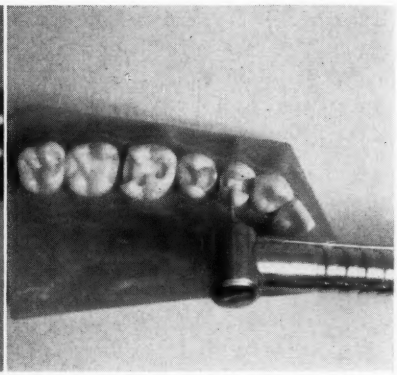


Fig. 10.

Fig. 9.—Rough surfaces are smoothed with a Rode No. 4MJ.
Fig. 10.—Fine finishing and grooves are accomplished with a Rode No. 1-1/2 MJ.

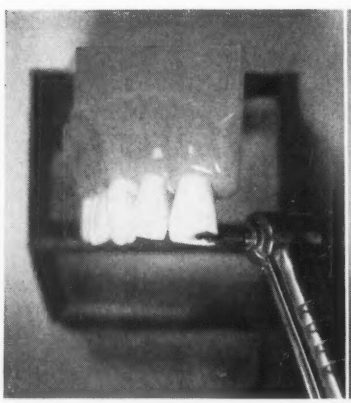


Fig. 11.

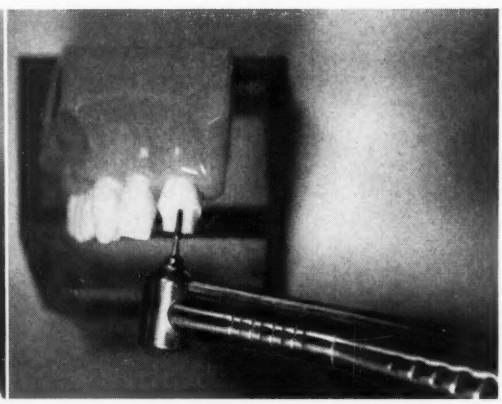


Fig. 12.

Fig. 11.—A jacket preparation. The occlusal surface is reduced first with a No. 171 carbide bur.
Fig. 12.—The interproximal and labial surfaces are reduced in steps with a No. 171 carbide bur.

The Star Company manufactures a special mandrel for paper disks. At ultra high speeds the heat generated by these disks is very damaging. A large amount of water spray should be directed on them while in use.

With all cutting instruments, a planing type of cut[6] is the most effective for control. This practice of removing a small amount of tooth structure at a time allows the smaller tool to reduce very large tooth areas rapidly.

A certain amount of energy is transmitted to a tooth when it is prepared. If too much heat is absorbed, the tooth, the pulp, or periodontal membrane will be damaged. The feather-like touch of the ultra high speeds, combined with sufficient coolant,[7] leaves pulps in a much healthier condition than low speeds due to lessened trauma of heat and motion.

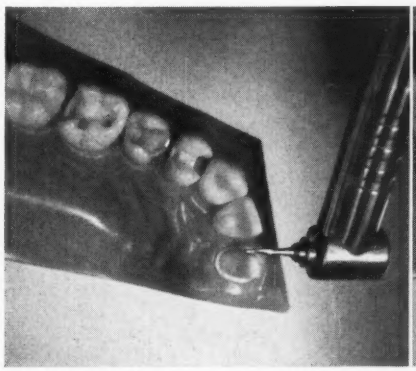


Fig. 13.

Fig. 14.

Fig. 13.—The shouldering is done with the No. 171 carbide bur.
Fig. 14.—The palatal and lingual surfaces are reduced with a 110S Star.

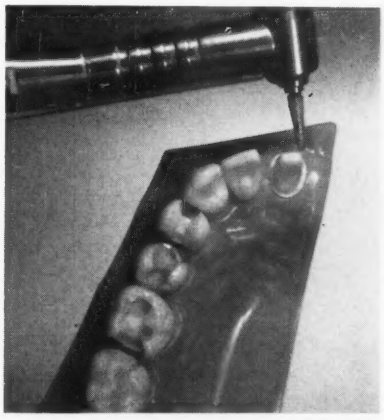


Fig. 15.—The fine finishing is done with a No. 4 or No. 6 Rode MJ.

When using the small end burs, such as No. 3, 4, 6, and No. 33⅓, 34, 35, 37, it is important to guard the shank of the instrument from touching the walls of the preparations, as the shank creates an excessive amount of heat, due to its burnishing action.

The Rode diamond numbering system is used because these diamonds performed best in my hands, and they have slotted shanks which allow the excess lubricant in the chuck escape. However, similar shapes in Densco, Chayes, and Star diamonds gave excellent performance. Other shapes and sizes of instruments

can be used according to the individual dentist's choice. Some dentists have good success with special shouldering instruments. A greater selection of ultra high-speed instruments will be available in the near future.

Ready access to a pulp chamber, even though an acute pulpitis and pericementitis is present, can be gained by a new sharp No. 4,* No. 2** round carbide. Vibrational discomfort is at a minimum with the ultra high speeds.

SUMMARY

A procedure for the use of ultra high speeds in general dentistry has been presented.

Unquestionably, this new concept on tooth preparations has proved to be a great boon to both dentists and patients, due to the lack of vibration and ease of cutting.

The dentist will find that all preparations can be done with the minimum number of cutting tools. The use of the disk is entirely eliminated in all cutting procedures.

Patients will have healthier pulps due to the light cutting touch and use of a coolant used with high-speed equipment.

Over 40,000 dentists are using handpiece speeds of over 60,000 r.p.m. Many dental schools are including it in their undergraduate curriculum. It can be foreseen that, in a very short time, this procedure will be routine in most dental offices.

The author is indebted to the following manufacturers for their invaluable technical help in preparing this report: Chayes Dental Instrument Company, Densco, Emesco, Foredom, Hanau, Kerr, Midwest, North American Philips, Pfingst, Ritter, Rode, Super-Dontic, Star, Weber, and S. S. White.

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*Belt driven.
**Turbine driven.

FUNDAMENTAL PROCEDURES IN GOLD FOIL OPERATIONS

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THERE IS A RAPIDLY growing interest in gold foil and an urge on the part of many good operative dentists to obtain greater knowledge and skill regarding its use. Articles have been written on the virtues of gold foil, the use of the rubber dam, certain variations in gold foil cavity preparations, and the condensing of gold foil. In this article, I intend to stress the basic fundamental procedures embracing teamwork, instrumentation, standardization of cavities, condensers, and the condensing of gold foil. It is only after these fundamental procedures are fully understood and executed with skill that we are in a position to make changes such as minimizing labial outlines or variations in methods of condensing gold foil.

THE RUBBER DAM

Nothing is more fundamental in gold foil procedures than the use of the rubber dam. As a component part of the over-all operation, the rubber dam technique should be so standardized that the teamwork between the assistant and the dentist becomes a flowing of steps. Each movement of one coordinates with that of the other. In this manner, the rubber dam is placed every time so that it covers the same number of teeth for a given operation. For example, when a gold foil restoration is to be placed in any of the four anterior teeth, the rubber dam would be placed on all teeth from cuspid to cuspid. For these restorations in the cuspid or bicuspids, the rubber dam would be placed on all teeth from the first molar to the central incisor. Other than this, the rule is that the rubber dam be carried to the tooth distal to the one being operated.

It is basic to use a ten one-thousandth thickness of rubber dam, 6 inches square. This weight of rubber dam is designated as extra heavy, and it is slightly more difficult to pass between the contact areas than a light rubber dam would be. A firm stretching of the rubber, together with the passing of the ligature, one lip of the rubber dam preceding through the contact, makes the operation most simple. However, the advantage over the light or medium is startling. There will be no folds, and the steady pull on the gingival tissue in the embrasure permits the proper placing of the gingival cavity outline. The invagination of this heavy dam around the teeth maintains a tight seal. In short, the entire operating field leaves little to be desired.

Read before the American Academy of Gold Foil Operators Meeting, New Orleans, La., Nov. 1, 1957.
Received for publication Nov. 27, 1957.

RUBBER DAM CLAMPS

The standardization of rubber dam clamps has been badly abused. Many dentists have tried to use too many clamps. Trial and error procedures have resulted in wasted time and money. In my hands, the best universal rubber dam clamp for upper molars is the S. S. White No. 18 (Fig. 1). While it can be used as a splendid universal clamp, in most cases, there are times when it will not balance due to the fact that both jaws of the clamp are the same shape. Two clamps that will fill this need are the Ivory 12 A and 13 A (Fig. 2), but to be usable, these clamps must be altered by cutting away the wings and refining the jaws. My choice for a lower molar clamp is an S. S. White No. 26 (Fig. 1). Rare, indeed, is the time when one of these four clamps cannot be used with rigidity and firmness on any one of the molar teeth.

Fig. 1.

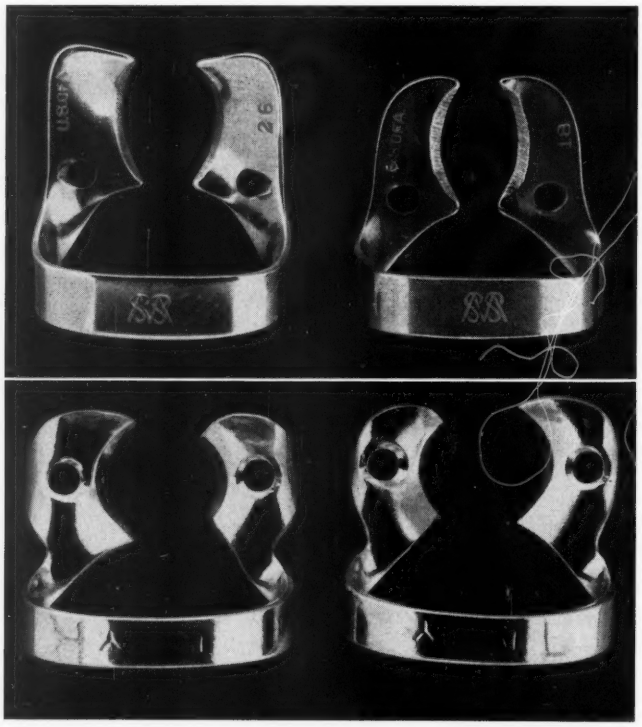

Fig. 2.

Fig. 1.—Universal molar rubber dam clamps.
Fig. 2.—Modified upper molar rubber dam clamps.

OUTLINE FORM

It is not my purpose in this article to give a technique in sequence for the Class III or Class V gold foil operations but rather to assert and emphasize certain fundamentals which are a part of these steps.

Nothing is more fundamental to gold foil restorations than cavity outlines, but they are abused so frequently. Many uninformed dentists have told me in an

apologetic manner that their patients would not permit gold to be placed in the front of their mouths. I usually tell them that they are talking about fillings which are so shaped that they reflect light as intensely as a small headlight. I am discussing a restoration for treating initial caries that is so linelike and in such perfect harmony with the tooth that it is not noticeable. In teeth where extensive caries make this impractical, a compromise can be made, and baked porcelain inlays can be used. Many fine porcelain inlays still give good service after 25 years.

Great care should be exercised in establishing the outline form for a Class III gold foil, and it should be completely accomplished before work is done on the interior form of the cavity. A delicate, keenly sharp, 11.5 mm. width, reverse bevel chisel is used to form an abrupt curve in the incisal one-third, and a straight line margin is carried toward the gingiva to join the straight gingival outline. The gingival margin is placed just beneath the free margin of the gum tissue, and the straight labial line is in harmonious parallel relation to the lobe of the tooth. This Class III outline should be so linelike and so parallel to the lobe of the tooth that it takes careful observation to be seen. The outline form is conservative and yet, with slight separation, the cavity can be filled from the labial surface for the major portion of the malleting. The lingual outline form is cut in a similar manner to join the gingival margin with a shoulder. The linguogingival shoulder and the lingual surface is malleted from the lingual side of the tooth.

Too little time, consideration, skill, and care is given to the outline form by nearly all gold foil operators. Initial caries occurring in the distal surfaces of central or lateral incisors or cuspids can be restored with gold foil and should never be objectionable. Yet, if the outline form is slightly out of harmony, overcut, or with irregular margins, the completed foil will rightly bring unhappiness to a patient with a pride in appearance. A skillful dentist also need feel no hesitancy in filling initial caries in the mesial as well as distal surfaces of anterior teeth with gold foil.

INTERIOR CAVITY FORM

The interior form of the cavity consists of an axial wall encompassed by labial, lingual, and gingival walls with their line angles and point angles. The retention is provided between the gingival wall and the incisal angle. It is fundamental in the instrumentation of the Class III cavity preparation that the hoe, angle formers, and axial wall plane be used in a cutting manner with the blade parallel to the wall, rather than by a digging action.

MALLETING AND CONDENSING GOLD FOIL

A few fundamentals in the malleting and condensing of the Class III gold foil must be respected. The proper condensing instruments must be used for the specific purpose for which they were designed.

A suitable holding instrument must be used to receive and hold the first few pellets positioned in the cavity for malleting. The following sequence of use of condensing instruments is effective: Carlson-type Ferrier condensers of 0.5 and 0.55 mm. in diameter (No. 1 and No. 2) and having an angle of seven degrees

permit the dentist to work around the adjacent tooth and to maintain a proper line of force into the cavity for adequate condensation.

A No. 6 S. S. White bayonet with a 0.5 mm. condensing point and occasionally No. 8 and 9 Ferrier bayonets can be used to advantage. These condensers permit the proper line of force to be directed into the labiogingival point angle and the incisal point angle.

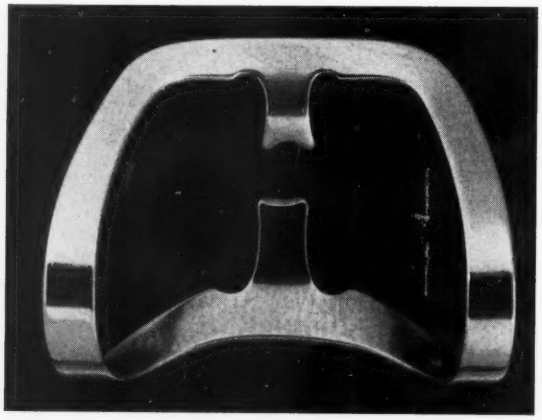

Fig. 3.—A universal gingival (rubber dam) clamp designed by W. I. Ferrier.

A Ferrier F. foot condenser which has a diameter of not over 0.55 mm. is used to assure condensation of the foil over the cavosurface margins in areas of difficult access, such as the middle third of the gingival margin, the linguogingival shoulder, and possibly over the contact area. While these instruments are fundamental, Dr. Alex Jeffery has designed some bayonet condensers for use in the invisible Class III foil. These have short nibs and greater offsets, making them very useful in difficult Class III work.

Gold foil cannot be wished to place. The middle third area of the gingival wall at the cavosurface and the linguogingival angle at the cavosurface must be stepped and condensed before the mass of subsequent gold cuts off the access. To correct an error at this point can be an onerous chore.

CLASS V GOLD FOIL FILLINGS

A fine gold foil filling is the most enduring restoration for gumline caries or erosion. In only a few mouths are they noticeable and then only in a wide smile.

The Class V gold foil presents different problems from those of Class III fillings. The gingival wall of the cavity should be placed gingival to any evidence of erosion or caries and where it will be covered by gingival tissue. There should be just enough cementum between the gingival outline and the labial jaw of the gingival clamp for proper finishing. The mesial and distal outlines should be placed so that the gingival tissues in the embrasures will cover or very nearly cover them. It is better for the outline form of the cavity to be overextended than to be underextended.

The S. S. White No. 212 gingival clamp (Fig. 3) should be used universally for all teeth except molars, and even there it will be found to be very usable. The labial bow of the clamp allows an excellent working field without interference, and the labial jaw slopes to approximate the gingival tissue, thus permitting the placing and cutting of the gingival wall of the cavity. In accomplishing these features, this clamp could not be made to balance without support. However, with a purposely blunt labial jaw, it may be slid to place and, while it is held in position, it can be blocked with compound.

The fundamental instrumentation for Class V cavities consists of outlining the cavity with a 33½ inverted cone bur. The end cutting surface is used on the gingival, mesial, and distal walls, and the side of the bur is used to make the incisal or occlusal outline. The incisal or occlusal outline may be developed more rapidly by the use of the small straight diamond wheel. This instrument should not be used in a high-speed handpiece, however. The walls and interior of the cavity are finished with the Nos. 21, 22, and 23 hoes. The retention in the finished cavity is provided between the gingival and incisal or occlusal walls and their line and point angles. The mesial and distal walls are obtuse and flaring from the axial wall to give proper strength to these portions of the tooth.

For Class V cavities, the straight condensers having diameters of 0.5, 0.55, and 0.6 mm. are fundamental. It will be noted from these dimensions that the condensing area of these instruments is very small. Yet, with accurate stepping, a fast malleting cadence by the assistant, and by using an easily controlled instrument it can produce a better result rapidly. All mechanical condensers have annoyingly cumbersome tubes, and a mechanical handpiece must be tripped in order to step. It matters not how many blows are delivered; time is lost in the tripping of the instrument. The average Class V foil should require no more than 15 minutes of hand malleting time. In stepping the plugger point, it should be watched constantly to avoid possible pits in the gold from uneven stepping. Each step should overlap the preceding one by half. The surface of the gold should not be burnished, but it should be condensed and flowed against the cavity walls for a tight seal. In emphasis I repeat, the average Class V foil filling will take from 12 to 15 minutes of hand malleting time. I know of no mechanical condenser using the same size condenser point that will equal this.

VARIATIONS IN TECHNIQUE

There seems to be considerable interest in several variations of the standard technique. Among these are (1) the use of mat foil, (2) the use of large foot pluggers, and (3) the use of new mechanical condensers. All of these are used for the obvious purpose of saving time. However, I suggest that fundamentals be thoroughly understood before these variations are attempted. It would seem to be unjustified for a dentist to carefully cut a fine detailed cavity with line angles, point angles, and true walls, only to introduce large masses of gold foil which cannot be condensed completely into these angles.

Little purpose is served, although it is interesting to make metallurgical tests of finished malleted foil fillings. Samples made by two different dentists using the

same technique will show a different result. A specimen produced on a laboratory bench for the purpose of test will vary, no doubt, from one produced in the mouth. Therefore, we may assume that whatever the technique (whether a combination of soft and cohesive foil, mat foil with a veneer of cohesive, or cohesive foil alone), gold foil must be properly stepped. It must be condensed with a small plugger point, and it must be flowed against the walls with the proper line of force to obtain a perfect seal against the tooth. These are fundamentals.

GOLD FOIL PELLETS

Since time is a fundamental factor in the production of a gold foil restoration, the dentist can ill afford to use a manufacturer's pellets. Many years ago, hand-rolled pellets were supplied by the manufacturer.* The resultant shortage of help during the war years caused them to discontinue this item. However, a skillful assistant, with practice, can roll a full book of gold foil (one-tenth of an ounce) in an hour and a quarter so as to produce pellets in four sizes.

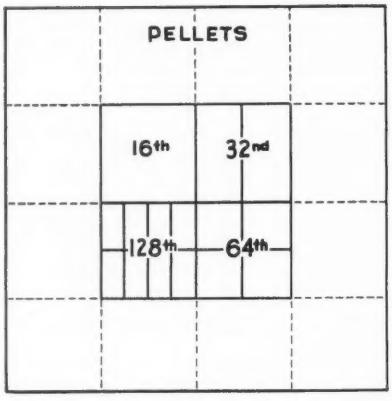

Fig. 4.

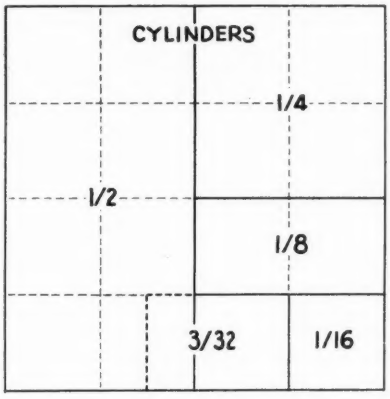

Fig. 5.

Fig. 4.—The plan for cutting a sheet of gold foil for the hand rolling of pellets.
Fig. 5.—The plan for cutting a sheet of gold foil for forming cylinders.

Each book of No. 4 soft gold foil should be first marked and drawn into 16 1-inch squares (Fig. 4). The full 1-inch square becomes the 1/16 pellet, which is the largest size. To make the 1/32 pellet, one more cut is made, leaving a piece 1/2 by 1 inch. The next smaller size is the 1/64 which measures 1/2 by 1/2 inch. The smallest pellet is the 1/128 which measures 1/4 by 1/2 inch.

All of these are rolled in much the same manner. After separating the gold from the dividing paper, the cotton pliers are used in the right hand to grasp each piece in the center, crumpling it slightly, until the corners all turn up as it is placed between thumb and forefinger of the left hand. With a light touch of the pliers, the corners are tucked into the center as the fingers gently roll the gold into a ball. Thus, the corners are within the pellet and not on the outside of the ball of foil.

*The J. M. Ney Co., Hartford, Conn.

GOLD FOIL CYLINDERS

The technique for using hand-rolled cylinders to line Class V cavities is not fundamental, but it is far superior to one of using only cohesive foil. The advantages are better protection of the margins and reduced malleting and finishing time. Hand-rolled cylinders for Class V cavity use are the 1/16 and 3/32 of a sheet of gold in size (Fig. 5). They are made by creasing the piece of foil with a straight edge plaster spatula and folding it without pressure several times into a soft ribbon. Starting at one end of the ribbon with a jeweler's broach, it is rolled without pressure into a small cylinder. They are used in the Class V cavity by introducing and flattening one against each of the four cavity walls. Cohesive foil is then placed into the axial wall and condensed, with succeeding pellets being built up to the proper form. Subsequently, the remaining soft foil is pinched off over the margins.

The "invisible" Class III foil filling is not classed as a fundamental. This type of cavity is difficult to cut and difficult to fill and, while it is not beyond the scope of skillful gold foil operators, an overemphasis on this type of restoration with its possible uncertain results may bring discouragement. A technique which is difficult to standardize and not frequently indicated is not fundamental.

FINISHING THE RESTORATIONS

The finishing of the gold foil filling with the painstaking care and precision required to restore the original anatomy of the tooth is more time-consuming than the malleting. Beveled files, knives, and extra long (18-inch) strips, and sparing use of sanding disks are used for this purpose. Great care must be exercised to avoid ditching or abrading margins of the cementum in any way.

In a discussion of fundamentals, the motive involved is an honorable one. It seeks to call attention to definite procedures and techniques and an armamentarium which, when used properly, will produce clinically beautiful enduring restorations. It has no quarrel or conflict with any other branch of the dental art. Its sole purpose is to bring about the saving of human teeth.

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ADJUNCTS TO MOUTH RECONSTRUCTION

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MORE OF THE PROFESSION should become specialists in the practice of good general dentistry. The general practitioner sees many patients with minor dental discrepancies, especially in the younger age group. Therefore, he is charged with the responsibility of correcting and maintaining the oral health of these patients for their entire life. This is a large order. The essential long-range view in diagnosis and treatment planning includes clinical and roentgenographic examinations, the use of study casts, proper periodontal treatment, and patient education for home care. A diagnosis made clinically, roentgenographically, and by accurately mounted study casts is most certainly in the realm of the general practitioner—*the operative dentist.* If he is not to render this service, *who* or what specialty is responsible for this service? The answer is the *dentist who specializes in the general practice of dentistry.*

The general practitioner plays an important role in the execution of a complete service to the patient. The adjuncts to be discussed help in the execution of this concept of modern dentistry. The assumption is that all dentists know, or should know, the techniques of mouth reconstruction. Each of the procedures involved in successful mouth reconstruction is contingent upon the other. Unless all of the procedures are properly carried out, there will be failure.

GOOD ADMINISTRATION OF THE PATIENT[1]

It is necessary to have the patient's confidence and cooperation. Prior to making the roentgenograms and diagnosis, the dentist speaks to the patient and arrives at an understanding regarding his dental health. The patient is encouraged to tell his story and the dentist listens. This is very important.

Certain hazards are involved in this procedure that are constantly in the picture. These hazards are any factors that may arise before, during, or after treatment that will militate against, weaken, or defeat the dentist's attempt to operate along the line of optimum dental health.

BASIC CONCEPTS OF GOOD PATIENT ADMINISTRATION[1]

Good patient administration requires that the dentist must (1) keep abreast of the advances of dentistry, (2) must make a careful and thorough diagnosis, (3) must formulate the one best treatment plan for the patient, (4) must render treatment with thoroughness and precision, (5) must, where economic means are

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limited, plan for the eventual *complete* treatment in stages to achieve the desired result (this desired result is the optimum in future dental treatment), and (6) must educate each patient so that he will be motivated and equipped to perform his part in maintaining the optimum dental health.

These concepts are the ideal and the pleasant way to practice dentistry.

PEACE OF MIND FOR THE DENTIST[1]

There are four hazards to overcome in order to maintain the peace of mind of the dentist. They are: (1) the fear of the fee on the part of the dentist or the patient, (2) the fear of pain, (3) preconceived ideas in the mind of the patient, and (4) a lack of dental consciousness on the part of the patient.

A thorough understanding of the treatment involved will eliminate all of these hazards that both the dentist and the patient have to face. Everything must be understood from the beginning. The average patient knows little or nothing about dentistry, so he should be shown that dentistry has made important changes and improvements. Patients should be shown why teeth are lost. This can be done by showing them roentgenograms and study casts.

USE OF A HIGH-SPEED ENGINE WITH JET AIR AND WATER COOLANTS

Dentists must concentrate on the patient's welfare and eliminate the hardships that accompany dental service. The new high-speed techniques are necessary adjuncts to the successful completion of the reconstruction service. When teeth are prepared for any type of restoration, the patient experiences an immediate discomfort. This discomfort should be eliminated or minimized by applying all the available implements.

High rotational speeds have many advantages. (1) They eliminate the need for local anesthesia during the first grinding on the tooth. (2) The high speed and water eliminates pain, vibration, and heat from friction. (3) The patient spends less time in the dental chair. This is especially important to a highly nervous patient who needs coddling. (4) At subsequent visits, the patient becomes acclimated to the grinding. Anesthesia can be administered, and preparations of individual quadrants can be completed. (5) High rotational speed reduces the time spent in preparation. (6) The dentist is less fatigued. (7) Impressions can be made with anesthesia, thus eliminating the pain related to making band impressions and requiring less time. (8) Two visits are essential for preparing the teeth in each quadrant. One is made with anesthesia and one without. At the second visit, the preparation can be re-evaluated and, under anesthesia, checks can be made for undercuts, chamfers, shoulders, and finishing lines. This seems to be the perfect procedure.

The advantages of high-speed techniques are greater than any possible disadvantages. Many hazards can be eliminated with the use of these new concepts of tooth preparation. Previously, dentists have prepared teeth at one sitting and have found defects in the preparations at the next sitting. Too often they did not correct the preparation but proceeded with the impression. These impressions were faulty, and the entire restoration was a failure. The dentists were fearful

that the patient would complain of pain, discomfort, and additional nervous strain of further preparation. With the use of carbide burs, diamond disks and wheels, and a high-speed engine, the preparation could have been altered in a matter of seconds, with little or no discomfort to the patient.

PREPARATION BY QUADRANTS

The technique of preparing quadrants of teeth with the minimum of fatigue has a direct bearing on the high-speed technique. The mouth is divided into four quadrants if the entire dentition is to be restored. It makes no difference whether inlays, full crowns, veneers, or platinum-porcelain restorations are to be placed.

The preparation of the tooth or teeth in the quadrant is started without anesthesia. At the conclusion of this session, the teeth are covered with aluminum shells or other temporary restoration. At the following visit, the patient is given anesthesia, and the preparations are completed. Impressions are made, and the prepared teeth are covered with splints or individual crowns. These impressions can be made without pain because of the anesthesia, and the patient is not fatigued at the time this is done.

TEMPORARY SPLINTS

The patient's welfare is of primary importance. The use of temporary stopping is inadequate protection for teeth in this concept of restorative dentistry. With full coverage restorations, the need for maintaining spaces which are to be subsequently restored with permanent restorations is apparent. The fabrication of these restorations may take weeks or months. The patient is subject to discomfort, pain, loss of vertical dimension, centric occlusion, etc., in this period. Splints will provide the type of temporary restorations that are needed.

At the conclusion of the first grinding on a quadrant, an impression for constructing the splint is made. After the enamel of the teeth has been removed, there are spaces between these prepared teeth. Pieces of wax are inserted in the spaces, aluminum shells are placed over the primary preparations, and an alginate impression is made.

If the patient is to be seen within a few days, the impression for the splint could be made at this time and placed in water until the next visit. If a longer interval between appointments is required, the alginate impression is made at the second visit when the preparation of the teeth is completed. The alginate impression is filled with self-curing acrylic resin and placed over the prepared teeth. When the resin has hardened (5 to 7 minutes), the impression and the resin is removed, and the excess resin is trimmed away. This provides a space maintainer, coverage, and protection for the teeth. The temporary splint is seated with temporary cement.

ELIMINATION OF PAIN

The elimination of pain is of vital importance in this type of dentistry. The patient suffers postoperative sequelae, once after the grinding, next after the im-

pressions, and during the waiting time between appointments which is required for laboratory procedures. We must concentrate on the patient's welfare and attempt to eliminate the hardships that accompany the treatment. There are many ways of eliminating pain. A properly constructed splint, cemented with an anodyne cement, will eliminate most of the discomfort. To be effective, the temporary splint must cover the prepared teeth at the gingivae. The use of silver nitrate, calcium hydroxide, Cavitec, and other quieting agents will tend to eliminate the discomfort.

The hazards accompanying full coverage must be taken into account. Care should be taken to avoid cutting into the horns of the pulps. If this should happen, it might not become apparent for 6 months after the preparations are completed. Temporary cementation should be employed until the danger period is past.

BISCUIT BAKE SPLINT

In any restoration where the entire mouth or dental arch is involved, a registration of the maxillomandibular relations can be made while the restoration is being completed. This is done by means of the "biscuit bake splint." When the laboratory work is completed and the restorations are ready for a trial insertion, an impression is made over the restorations. This is done in the same manner as for splint impressions. The restorations are removed from the teeth, and self-curing acrylic resin is placed in the impression and inserted in the mouth. When the resin is set, it is removed and trimmed. It is a duplicate of the metal restorations in acrylic resin. When this is cemented in place with temporary cement, the occlusion, esthetics, patient's comfort, and many other details can be observed and tested.

BINOCULAR LOUPES[2]

With high rotational speeds and full coverage, it is important that the dentist *see* what he is doing. The use of binocular loupes is essential.

COPPER BAND IMPRESSIONS

There is no margin of error in making copper band impressions. When there is a failure, there is a work stoppage, and this is expensive. The work cannot progress until a new impression is made. Attention to a few salient procedures will help to reduce the number of failures. (1) The copper bands should be annealed. (2) The copper bands should be fitted properly. (3) *Low* heat compound should be used. (4) The copper bands should be festooned. (5) The compound in the band should be heated, placed on the tooth, and removed *without chilling* after it is semihard, and replaced immediately upon the tooth. It should be allowed to remain on the tooth until it is hard. It is removed by a straight pull and replaced in the same position and allowed to set very hard. By this procedure, any possible "undercuts" were relieved, and the modeling compound was allowed to harden completely while it was in position on the tooth. After it had hardened without chilling, it could be removed and reseated. This provides a test for the final position of the restoration.

On very sensitive teeth where there is a danger of pulp irritation or pain, the rubber or hydrocolloid materials can be used for making impressions, but copper band and modeling compound impressions are best.

An over-all impression must be made with plaster of Paris to orient the various restorations in relation to each other.

CEMENTATION[3]

Temporary cementation is important to the success of extensive restorations. These restorations must be examined, periodically, at 6-month or shorter intervals. This has a direct bearing on the proper relationship between the patient and the dentist. A variety of temporary cements are available, and they should be selected according to the individual factors involved.[3]

Achromycin surgical powder mixed with the selected temporary cement prevents putrefaction and the odor that is characteristic of temporary cements after it has been in the mouth for a time. A small amount of this powder added to the temporary cement is effective.

SUMMARY

The general practice of dentistry requires that dentists be informed about the adjunctive treatment of patients as well as about the strictly technical treatments that are used. These are necessary for maintaining the most favorable relationship between the dentist and the patient. These adjuncts to dental treatment in restorative dentistry have been discussed.

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THE SUBJECT OF HIGH SPEED

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THE SUBJECT OF HIGH-SPEED operative instruments requires a critical review. With the present state of anesthesia and the general acceptance of anesthesia on the part of the public for all operative procedures causing appreciable discomfort, it has seemed paradoxical that so much emphasis has been placed upon reduction of patient pain in the sales promotion of these newer instruments. If this lessening of pain in operative procedure is intended to imply lessened trauma to the dental pulp, then it is more understandable. There has been so much written, so much demonstrated, and so much lectured on these new instruments that there is no reason to go into any detail about them here other than to identify them. One thing, however, which has become evident as common to them all is the requirement for new skills and judgment, with ever vigilant caution.

The first of these newer instruments to become available to the dental profession was the Airbrasive. The hazards inherent in this equipment were such that the manufacturer wisely stipulated that the equipment would be sold only to those dentists who took a course in its use at one of several established training centers. Some dentists, particularly those with a bent toward research, developed an amazing skill with the Airbrasive. In general, however, the complications involved in its use and its certain limitations militated against increasing popularity. Today, relatively little is heard of the Airbrasive, and it is noted that Journals from time to time carry offers of sale of it as used equipment.

The Cavitron, an instrument utilizing ultrasonic vibrations through what might be described as preformed cavity formers and a slurry of abrasives, was introduced to the market perhaps before adequate research upon its effect on the dental pulp had been completed. This equipment, for various reasons of complexity, messiness, etc., has not achieved great popularity

HIGH-SPEED ROTARY INSTRUMENTS

The following discussion will deal entirely with high-speed rotary instruments used in operative dentistry procedures. It is these which have caught and retained the interest of the profession. The commercial exhibitors of these rapid rotary instruments at every dental convention monopolize the attention of dentists. It is exceedingly unfortunate that the term "high speed" was applied to these rotating instruments in the beginning. Granted that it is hard to think of a more descriptive term, nevertheless, the term itself has been applied to the operating process in such a way that it implies *hurry* to the uninstructed many. The sad connotation

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is "high-speed dentistry." A glaring example was in an advertisement in one of the free commercial Journals which goes to virtually every dentist in the United States. This advertiser, who had shown such discretion in bringing forth the Air-brasive equipment, referred to the Airotor with speeds of 100,000 r.p.m. up to 250,000 r.p.m. as a great contribution to *"high-speed dentistry."* To realize the seriousness of this connotation "high-speed," it is only necessary to mingle in the crowd about one of the commercial exhibits demonstrating one of these instruments and listen to the discussion. The concern seems to be almost exclusively in how short a time a preparation may be completed, not how well.

A number of highly competent dentists have admitted to a sense of necessary haste when first using more rapidly rotating cutting instruments for operative procedures. In most instances, these experiences were with belt-driven, more or less conventional equipment. If such operators can be affected in this way, what may we expect from less expert and possibly careless dentists, thoroughly confused by the application of the term "high speed"?

TYPES OF ROTATING INSTRUMENTS

Some consideration of the characteristics of the various rotating instruments is indicated. Kilpatrick[1] divides them into three methods: (1) gear-driven equipment including straight handpieces and contra-angle handpieces, (2) belt-driven contra-angle handpieces, and (3) turbine-driven contra-angle handpieces.

It is recognized that there will always be a need for a dental handpiece usable at formerly conventional speeds upon occasion. For this reason, ball-bearing handpieces developed by several manufacturers meet a dual need in that they may be operated at speeds, varying from the usual 6,000 r.p.m. peak achievable with standard equipment, up through perhaps 24,000 r.p.m. with relatively simple adjustments. Such a handpiece, through the use of an oversize driving pulley on the unit motor, may perhaps be stepped up to 12,000 r.p.m. A switch arrangement allowing the cutting out of resistance to the motor will usually double the speed to 24,000 r.p.m. Various types of double-belt arrangements and, in some, gears, likewise, have been used with varying degrees of satisfaction, according to the dentist's desires. The development of ball-bearing handpieces, both for straight and contra-angle, has been a great boon to operative dentistry, even if used without increased rotating speeds. Among other improvements, it has required manufacturers to develop more accurately balanced cutting points.

PURPOSE OF INCREASED ROTATING SPEEDS

The purpose of increased speed of the rotating instrument is to increase cutting efficiency. This should mean to cut more rapidly, with less vibration, and to cut with less pressure, with resultant lower heat production, for the safety of the dental pulp. With each increase in rotating speed has come a corresponding reduction in torque. This is a decided safety factor and soon teaches the desirability of light pressure application, since excessive pressure will stall the revolving point. With the realization of the safety of the low stalling pressure, due to lowered torque, and the relatively lower frictional temperatures developed, it is

startling to recall that in a recent article in *Life Magazine*, devoted entirely to one of the high-speed mechanical handpieces and its inventor, the inventor is quoted as bewailing the loss of torque in his equipment and promising a future development which will produce a torque value similar to that of the conventional equipment rotating at 4,000 to 6,000 r.p.m. It would appear that this inventor should be an early candidate for some instruction in operative technique. The deplorable effects of such misinformation in lay publications will be obvious.

The hydraulically driven instrument now manufactured as Turbojet appears to have been the first departure from the mechanical drive principle in rotary cutting instruments. It has the desirable quality of very low torque, as well as supplying its own coolant to the revolving point. The torque on this instrument is so low that, running at better than 50,000 r.p.m., it has been demonstrated to be possible to stall a small diamond wheel on the wrist without laceration.

A more recent instrument available to the profession is the Airotor, which as its name implies is an air-driven turbine. This instrument has even lower torque than the hydraulically driven one. This equipment possesses certain advantages in size over the hydraulic turbine, but it brings in the complication of variable air pressures in most professional buildings. The turbine type cutting instruments definitely are adjuncts to the standard belt-driven type of handpiece. They undoubtedly supply the most effective cutting of tooth substance now known, and in capable hands, they have a strong safety factor in their low torque. The rapidity of their cutting action, however, presents a distinct hazard, especially in areas of difficult access. Control is dependent upon visibility alone, since the tactile sense is missing.

IMPORTANCE TO DENTAL PRACTICE

What has the phrase "high speed" meant to the practice of dentistry? To skillful and studious dentists, it has brought reduced fatigue, increased efficiency, and economy of time. To their patients, it has meant increased comfort, chiefly through reduced irritating noise and shorter operation periods. It will be noted that nothing is said here of reduced pain. Dentists of the type described have long years ago eliminated the pain of operative dentistry for their patients through standard, accepted methods of analgesia or anesthesia. To them, time has always been of importance, but always subordinate to patient comfort and welfare.

In the hands of the dentist who has depended for his knowledge upon advertising, the detail man, and the throw-away publications, it is to be feared that the term "high speed" has increased his vulnerability to malpractice actions. While superficially it appears to have increased his production, it has nevertheless laid upon him some headaches and worries that would make a migraine sufferer gloat in his freedom from pain. For the patients of this latter type of dentist, it has meant catastrophies to an innumerable host of dental pulps and a rapid approach to complete dentures.

FULL COVERAGE RESTORATIONS

A trend which has appeared to permeate the profession with the introduction of high-speed rotary equipment is the increased application of so-called full cover-

age operative procedure. This is most notable when fixed prosthodontics are involved. Possibly in days of greater operative difficulty, full crown restorations were avoided at times when they might have been the indication of protective choice. Today, however, it appears that the rapid and easy reduction of tooth substance and contour has led many dentists into unwarranted destruction of tooth substance. An example is a man recently examined, approximately 30 years of age, an actor, who within the year had had twenty-eight crowns placed on his teeth. This work had been done in a large New York "clinic." It was quite well done. The occlusion and color were good. The hinge axis had been determined, and proper jaw relations had been established to produce a very creditable result. The porcelain on the mandibular right second molar had fractured, leaving a troublesome sharp place. This patient had applied for treatment in New York originally to correct a diastema and somewhat protruded maxillary incisors. By his report, dental decay had not been excessive. He was persuaded to have the entire twenty-eight teeth treated in this manner "in order to prevent any further tooth decay." The improved appearance was a factor, of course, but it was minimized, in the opinion given supporting the full mouth reconstruction, as being secondary to the preservation from future tooth decay. The gingival tissues about most of the teeth showed passive congestion, hypertrophy, and a flabby tone. No effort whatsoever had been made to educate the patient to proper daily maintenance.

It was pointed out to the patient that, unless he undertook vigorous personal hygiene measures, he would soon experience further bony absorption with the exposure of all of the cervical margins of the restorations. It is a very rare instance when one sees this many crowns in a mouth, without finding gingival inflammatory conditions about some of them. There is no artificial material tolerated by the gingival tissues as well as is natural tooth substance. Undoubtedly, gold foil, correctly inserted, is the best tolerated of the artificial materials. It seems highly probable that had preparation of these twenty-eight teeth been as difficult in 1957 as it was in 1937, the patient would not have had twenty-eight full crowns in his mouth.

CONCLUSION

Unless steps are taken to bring adequate instruction to the vast majority of dentists who are influenced to use high-speed rotary instruments, it may be anticipated that an era of slovenly cavity preparation will plague dentistry for some time to come. The effect on the public esteem for high quality operative dentistry, which we have all striven to establish, is unpleasant to contemplate.

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MAXILLOFACIAL PROSTHESIS

MECHANICAL STABILIZATION OF DIFFICULT MAXILLOFACIAL APPLIANCES

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MEDICINE AND SURGERY HAVE recognized the necessity of combining reparative surgery and maxillofacial prosthesis for the repair of facial defects. This is especially true in deformities about the face and jaws when success of plastic surgery depends, among other things, upon the restoration of the normal contours of the region involved. In order to establish that contour, we must recognize the importance of the underlying framework over which soft tissues are to be repaired. If bone or cartilage is missing and if it cannot be adequately replaced by a plastic surgical procedure, prosthetic appliances can be used either as a temporary measure or as a permanent restoration. This situation exists frequently when the teeth and alveolar process and part of the maxillae or mandible are missing.

Fixation is often a difficult problem when treating malformed mouths for young patients who have lost most of their deciduous teeth through neglect, for the adolescent when permanent teeth are erupting and cannot be used for retention, and for the adult who is edentulous. Some type of retention must be utilized for the stabilization of appliances when clasps and the conventional type of restorations cannot be used.

Loechler* recognized this problem and used the button type tissue implant for a patient in 1952. This appliance is still being used by the patient. At the present time, he has approximately 180 button type implants in use. Gustav Dahl and Hans Nordgren of Sweden developed the button implant procedure about 1940. Nordgren has reported thirty restorations of this type functioning successfully for periods ranging up to 10 years. To this time, button type implants have been used for about 725 patients.*

The button type implant is a chrome-cobalt collar-button-shaped insert, the base of which fits into the denture base, with the head exposed to fit into the gum tissue (Fig. 1).

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*Philip Loechler, personal communication, June 10, 1956.

THE TECHNIQUE

The basic appliances are constructed by following a recognized procedure,* and must be perfectly adapted to the supporting tissue. Roentgenograms of the jaws are made to determine the thickness of the soft tissues, to locate the sinuses of the maxillae, and to locate the mandibular canal if lower stabilizers are to be used. The selected locations on the ridge where the stabilizers are to be placed are marked with an indelible pencil. The appliance is placed in the mouth to transfer the indelible marks to the appliance. The areas where the stabilizers are to be placed are anesthetized. A cross incision about 2 mm. long is made to the bone over each indelible pencil mark (Fig. 2). The stabilizer is tested during function to de-

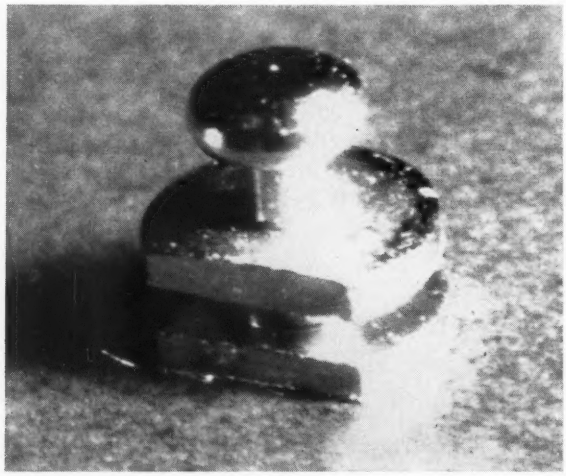

Fig. 1.—The chrome-cobalt implant button is used as the stabilizer. The base is attached to the denture base and the head fits in gum tissue.

termine if the head contacts bone when the tissue side of the base of the stabilizer is contacting the mucosa. If the head of stabilizer contacts bone, the bone is reduced with a No. 9 round bur until the head of the stabilizer is free of interference. Holes are drilled in the appliance with a stabilizer bur where the indelible spots are marked, and undercuts are prepared in the receptacles. The preparations in the appliance are filled with an autopolymer resin, and the appliance is inserted immediately over the stabilizers (Fig. 3). The acrylic resin is allowed to set, and the excess is removed. The stabilizer appliance is inserted in the mouth, and the patient is dismissed with positive instructions not to remove appliance until he returns on the fifth day, at which time the appliance is removed, cleaned, sterilized, and reinserted.

On the tenth postoperative day, when the patient returns, the appliance is removed and sterilized. The patient is given instructions to remove and clean the appliance three times a day and to rinse the mouth with aromatic Chlorozine mouth wash until the tissue is completely healed. Healing requires approximately thirty to forty days, after which the appliance is cared for normally. The patient must

*J. P. Knowlton, personal communication, Oct. 17, 1955.

be cautioned that the stabilizer appliance must not be left out of the mouth for a long period of time, for if this is done, the retention space in the mucous membrane will close.

The process of tissue repair is that of healing by secondary intention or by granulation. The essential changes are the same as in primary healing, except that they are more extensive. There is a prolification of fibroblasts and vascular endothelium which forms new connective tissue which replaces the lost tissue. This newly formed tissue is known clinically as granulation tissue because of its red granular appearance. Each granule represents a new capillary loop. Later, the granulation tissue becomes less vascular, contracts, and becomes scar tissue. At the same time, the surface of the wound becomes gradually covered by a proliferation of the epithelium. If it is necessary to remove bone to allow the stabilizer to seat, the repair is practically the same as that of the soft tissue, plus a deposit of lime salts, with osteoblastic action completing the bone healing. *It must be emphasized that there is no bone exposed. There must be soft tissue between the bone and the stabilizer.*

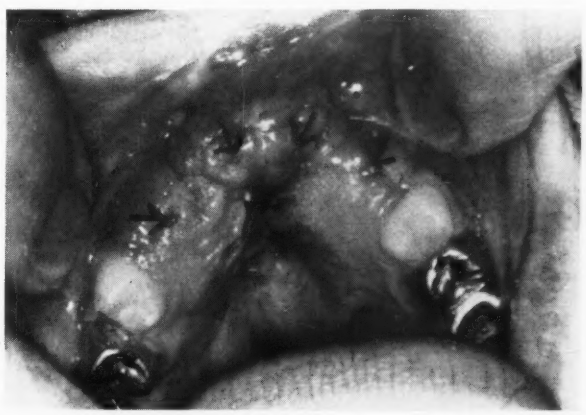

Fig. 2.—Arrows indicate the retention spaces in the mucous membrane after the appliance has been worn 10 days.

Fig. 3.—The button stabilizers are attached in the denture base.

CONTRAINDICATIONS

The use of stabilizers is contraindicated in certain instances. They should not be used on dentures where they will penetrate the sinus or mandibular canal, on ridges that have not healed, or on uncontrolled diabetics.

Twenty-two such appliances have been inserted under ideal conditions without any apparent failures. The healing has been remarkably fast and the results spectacular. Figs. 4 and 5 illustrate the use of the stabilizers as described for a patient with a repaired cleft palate and lip.

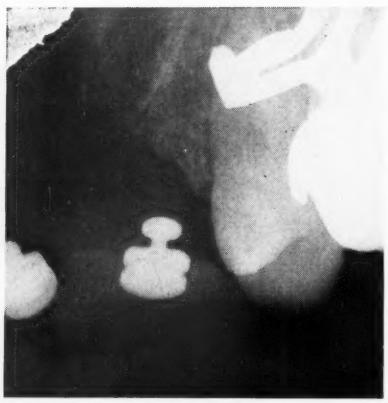

Fig. 4.—The roentgenogram shows the relation of the stabilizers to the tissues.

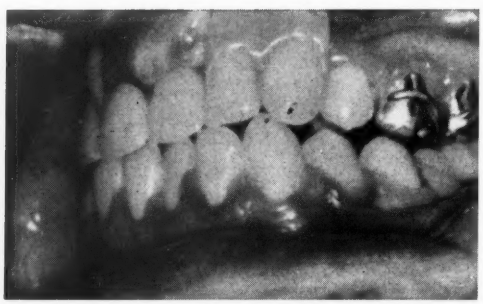

Fig. 5.—The appliance is seated in the patient's mouth.

CONCLUSION

When retention for prosthetic appliances is difficult to obtain, it is necessary to rely on some method other than the conventional ones. The tissue button implant is such a method. It is simple, hygienic, and provides good retention. The patient accepts the implant buttons with ease, comfort, and satisfaction. This is a further step toward improving prosthetic dentistry for the maxillofacial cripple.

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PROSTHODONTIC ASPECTS OF AN IMPLANT FOR HEMIMANDIBLE

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PROSTHODONTISTS ARE FREQUENTLY CALLED upon to fabricate appliances for use in oral surgical problems. During the treatment of a young white male soldier, resection of the left-half of the mandible for recurrent ameloblastoma became necessary. The Prosthodontia Section of Fitzsimons Army Hospital was called in consultation. In an attempt to alleviate the well-known deformities which follow mandibular hemisection, it was decided to fabricate an implant to replace the structure to be lost, working entirely from preoperative measurements and calculations. The preliminary success of the operation was so complete that the technical details of the implant fabrication are felt worthy of reporting. At the latest report, the implant had functioned successfully for fifteen months. If continued success of the implant warrants the reporting of the oral surgical aspects of the case, prosthodontists may well be called upon for their talents for implant fabrication.

TECHNIQUE

Surgical Vitallium was the material chosen for the implant because of the need for strength and for a material of proved tissue tolerance.

The first problem concerned the form to be given the implant. In consultation with the surgeon, it was decided to form the implant to permit the attachment of the masticatory muscles. If this was possible, it was felt that function could be preserved and the mandibular sideshift following hemisection could be prevented. Another consideration was the necessity to support the facial tissues and maintain facial contour. It was also thought that if the condylar element was given a shape approximating normal anatomy that less physiologic remolding of the glenoid fossa would be required than if an arbitrary ball-shape was used.

The second problem was one of measurements. To fabricate an implant preoperatively, accurate and adequate measurements were mandatory. To form the medial aspect of the implant to permit anchorage, it was necessary to determine the buccolingual widths of the mandible at all levels from the mesial side of the first premolar to the distal side of the second premolar, the site of the resection. Direct bone measurements were made by the Oral Surgical Section using local anesthesia. A draftsman's compass with needle points was used intraorally and extraorally. Considerable difficulty was encountered with the compass points slipping off the inferior border of the mandible. The angle at which the compass was held proved to be important in the measurements.

The opinions or assertions contained herein are those of the author and are not to be construed as official or reflecting the views of the Army Department or the United States Army at large.

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Large calipers and a face-bow were also used. Measurements of the width of the mandible were made extraorally in the region of the first premolars, the first molars, the angles, and the condyles. After making allowances for the tissues overlying the bone, a template was made from these measurements which represented an occlusal view of the patient's mandible.

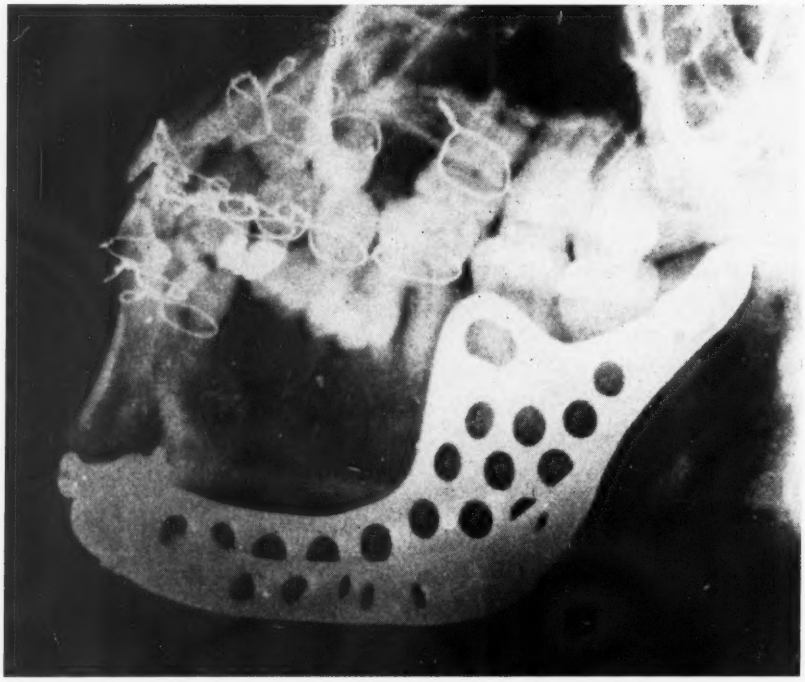

Fig. 1.—A postoperative roentgenogram of the implant.

The most valuable measurements were made on a roentgenogram of the left side of the mandible. A six foot target-film distance was used for making the roentgenogram. Using tracing paper, a template was made from this life-sized view of the left side of the mandible. The roentgenogram showed the vertical thickness of the mandible at the site of the considered resection, the length of the mandible to the angle, the angulation of the angle, the distance from the angle to the superior aspect of the condyle, and the shape, form, and size of the ramus.

After the measurements were completed, various dry skulls were examined. Fortunately, a skull with approximately the same measurements was available. Two elements of this skull's mandible were reproduced as a starting point for fabrication of a wax pattern of the implant: the left condyle and the region of the second premolar. An alginate impression of the entire left condyle was made. Melted green sheet casting wax was poured into this mold to provide a wax cast of the condyle. This cast was thinned on all aspects except the anterior and superior gliding surfaces. Another alginate mold was made of the left side of the mandible of the skull from the angle to the midline. This mold was poured in plaster. The

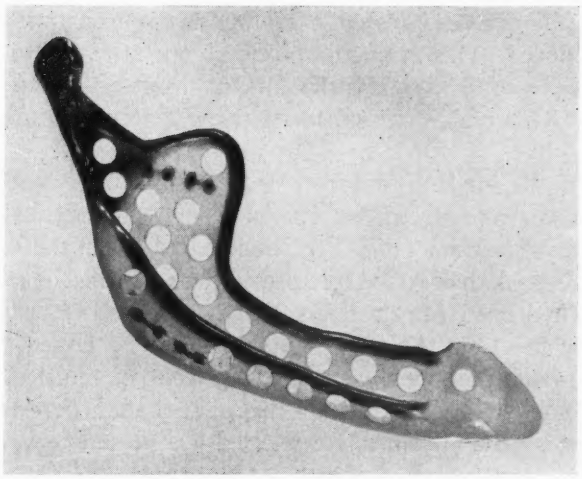

Fig. 2.—The wax pattern of the implant.

Fig. 3.

Fig. 4.

Fig. 3.—The buccal view of the implant.
Fig. 4.—The lingual view of the implant.

exact location of the proposed resection cut was marked on this cast and the cast was carefully sectioned. Then, using all of the preoperative measurements, the median portion was carved to what was thought to duplicate the patient's mandible in the same region. This cast was used to mold the anterior portion of the implant wax pattern.

The body of the implant wax pattern was formed of baseplate wax. The coronoid process was reproduced, but it was reduced materially in size as shown on the profile roentgenogram (Fig. 1). Rounded edges on the wax pattern were provided by the use of half-round preformed wax strips. Fenestration was accomplished with a heated copper impression band. Both loops and holes were provided for attachment of the severed muscles (Fig. 2). However, after consultation with the surgeon, the loops were removed from the finished casting. It was thought the smoother the casting the less chance of tissue irritation. The screws to be used for attaching the implant were selected by the surgeon. The holes in the wax pattern were countersunk, using the same screws to be used at the time of the operation. The final step consisted of a meticulous recheck of all measurements and a polish of the wax pattern with oil of eucalyptus, the excess of which was removed with acetone. The wax pattern was cast commercially of surgical Vitallium (Figs. 3 and 4).

On reflection postoperatively, one improvement in the pattern would have been beneficial; the attaching flange on the inferior border of the mandible could have been extended to the midline.

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TEMPOROMANDIBULAR JOINT ROENTGENOGRAPHY: AN IMPROVED TECHNIQUE

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TWO PIECES OF EQUIPMENT are necessary to secure temporomandibular joint roentgenographs: an x-ray machine, and a device to hold the film cassette in the proper relationship to the patient's head. Only when the patient's head is in an upright position can there be any significance to the position of the condyle

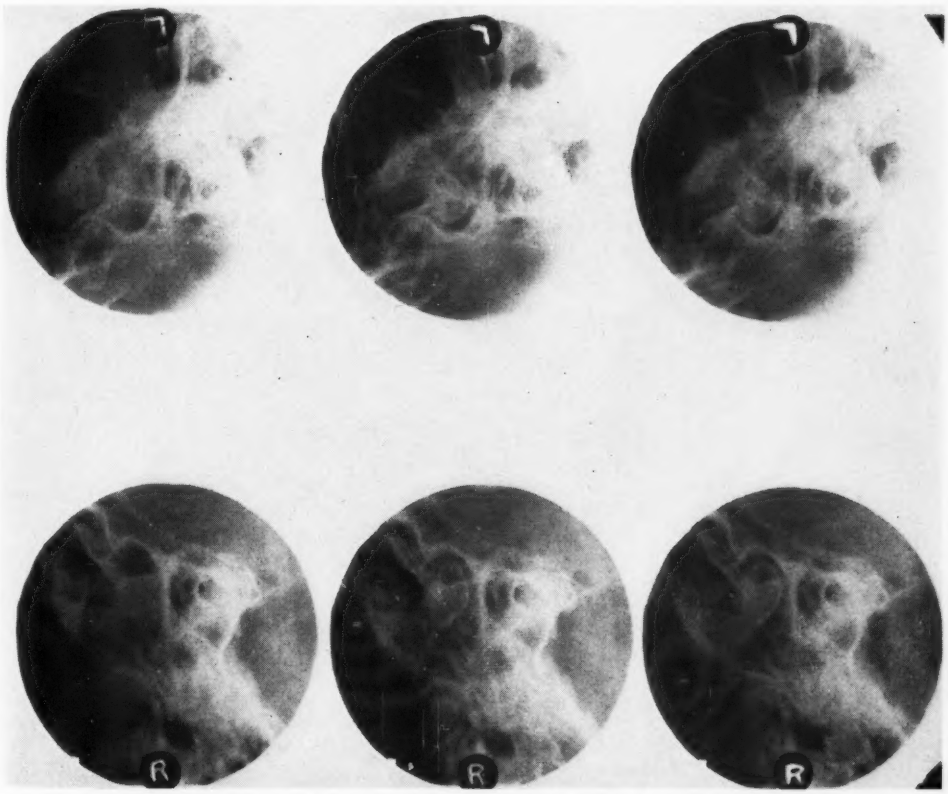

Fig. 1.—An 8 by 10 inch roentgenograph showing six views of temporomandibular joints made with the long cone technique with the head upright and held in the special head positioner. Although some of the circles are not completely filled, the diagnostic value has not been impaired.

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in the articular fossa. When the patient's head is placed on its side, as in the Updegrave technique,[1] gravity causes the mandible and the condyle to shift to that side, thus producing a distorted relationship. When the head is placed with the Frankfort plane parallel to the floor, the condyle will assume its postural position in the articular fossa, and a roentgenograph made in this manner with the mandible in its rest position can have important significance. Three roentgenographs of each joint are made in a 3-inch circle on an 8 by 10 inch x-ray film on each side. One is made with the teeth in occlusion, the second with the mandible at its rest position, and the third with the mouth opened as widely as possible. Blocks are not used between the teeth because they most often cause the patient to protrude the mandible.

Fig. 2.

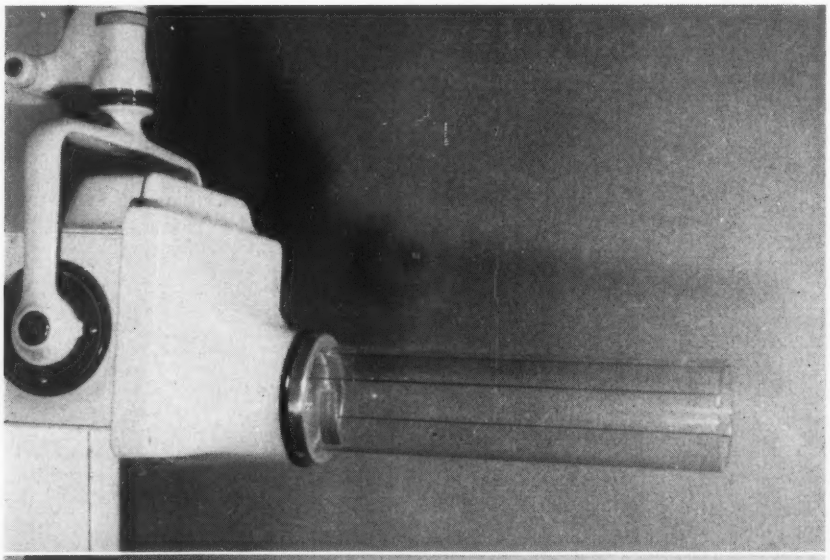

Fig. 3.

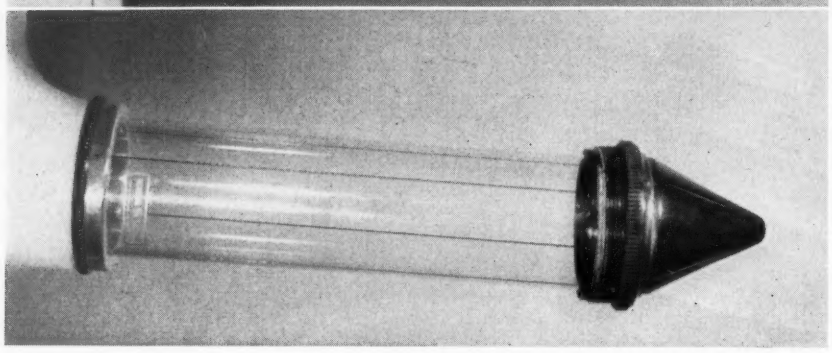

Fig. 2.—The Fitzgerald long cone.
Fig. 3.—The short cone is fitted over the end of the Fitzgerald long cone.

THE X-RAY MACHINE

The standard dental x-ray machine is satisfactory for temporomandibular joint roentgenography. I have modified the standard x-ray machine so that it

may be used to produce roentgenographs of superior diagnostic quality and to give the patient greater protection against excessive radiation.

Geffen* pointed out that a long target distance is necessary to reduce distortion and produce roentgenographs of good diagnostic quality of the mastoid bone and temporomandibular joint. Experimentation with a Fitzgerald long cone proved this to be correct, but this introduced other problems. With the long cone technique, absolute accuracy of aim of the rays is necessary if the entire area of the 3 inch circles of exposure on the roentgenographs is to be filled properly (Fig. 1). The slightest deviation of the angle of the central rays results in a partially filled circle, but while this is annoying, it does not affect the diagnostic quality of the roentgenograph. The advantages gained in quality more than overbalance the difficulty of obtaining the desired perfection. One advantage of inestimable value that is gained by using the long cone is that the amount of radiation to which the patient is exposed is reduced to approximately one-fifth of what it would be with a short cone. In using the long cone, a 0.5 mm. aluminum filter should be added to eliminate the soft nondiagnostic rays which are so harmful.

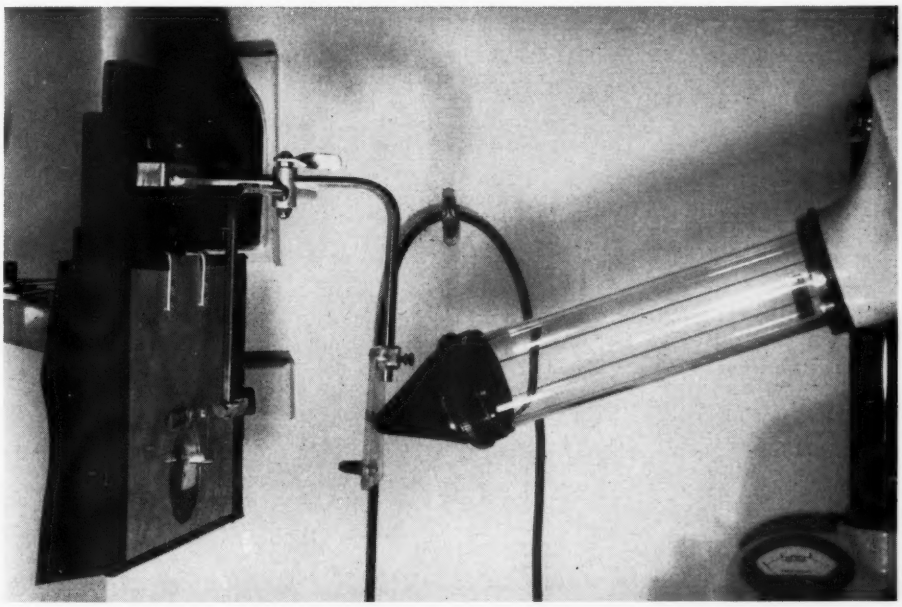

Fig. 4.—The addition of the short cone permits the accurate positioning of the x-ray machine. Note the ear plugs and the nose piece that hold the head in the correct relationship to the 3-inch exposure aperture.

The Fitzgerald long cone ends in a flat opening (Fig. 2) which makes it almost impossible to aim the central ray with sufficient accuracy. To overcome this problem, the interior of the standard short cone that was originally on the x-ray ma-

*Dr. Abraham Geffen, Attending Radiologist, Beth Israel Hospital, New York, N. Y., personal communication.

Fig. 5.—The head is positioned so that the Frankfort plane is parallel to the floor. Note the nose piece in position.

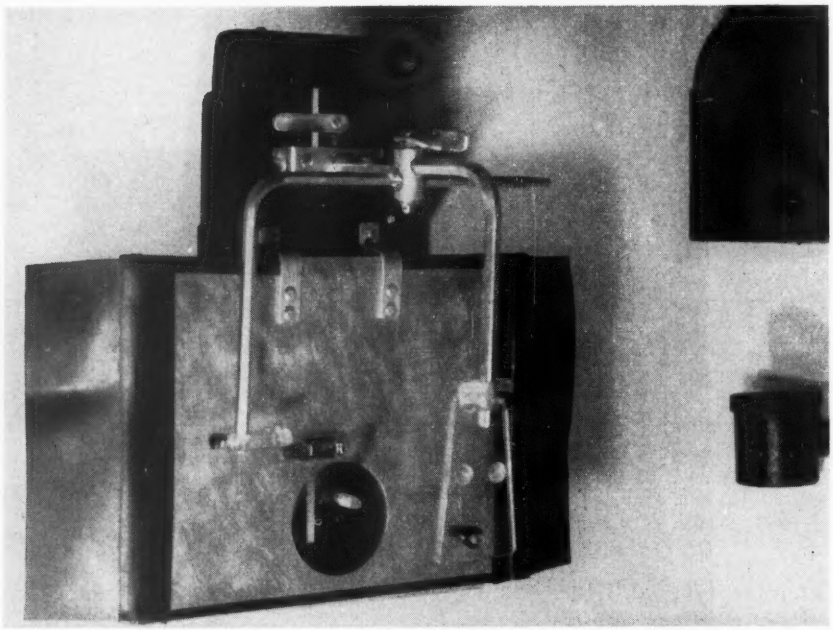

Fig. 6.—The positioning device and cassette holder. Note the 3-inch aperture in the lead cassette shield.

chine was modified so that it fitted accurately over the long cone (Fig. 3). Three advantages were obtained by this modification: (1) an accurate point was established for the central ray, (2) a method of lining the machine up with the positioning device was obtained (Fig. 4), and (3) the target film distance was increased another 4 inches.

THE POSITIONING DEVICE

The Atco Angulator positioning device is used to hold the patient's head in a position so that the Frankfort plane is parallel to the floor (Fig. 5). The head is held in this position by means of plastic plugs which fit into the external auditory meatuses and a piece of plastic which holds the bridge of the nose (Figs. 4 and 5).

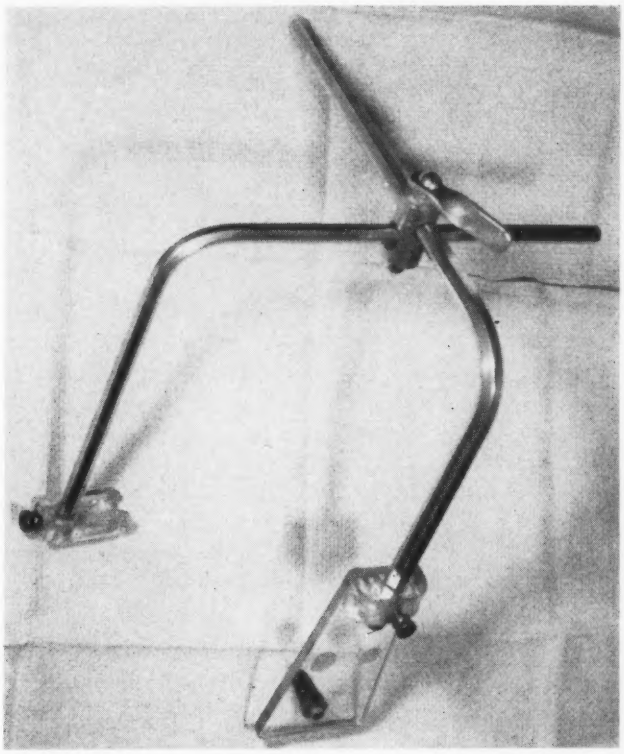

Fig. 7.—The outer part of the head positioner. Note the indentations in the flat plastic part for positioning the tip of the cone of the x-ray machine.

The ear plugs hold the patient's head in the correct relationship to the 3-inch circle which was cut in the lead shield that protects the cassette from overlapping radiation (Fig. 6). A sheet of transparent plastic with two indentations for the nose of the x-ray machine cone is attached to the outer head piece (Fig. 7). By using standard vertical (+15 degrees) and horizontal positions for the head of the x-ray

machine (as read in degrees marked on the machine), the roentgenographs can be duplicated at any time. Thus, it is possible to compare the changes in the joint which may occur over a period of time.

SUMMARY

1. A technique is presented for making temporomandibular joint roentgenographs which can be duplicated.

2. The use of a long cone technique gives roentgenographs of superior diagnostic quality and with markedly reduced exposure of the patient to radiation.

3. The device for positioning the patient's head permits the head to be in the upright position, thus providing an accurate picture of the postural position of the condyle in the articular fossa.

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New York 19, N. Y.

RESEARCH

ELECTROMYOGRAPHY IN DENTAL RESEARCH

Part II. Frequency Response Requirements

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TECHNIQUES FOR PLACEMENT OF electrodes for electromyography in dental situations were examined and evaluated and reported in Part I.[1] It became apparent in the course of that and previous work, that one of the criteria for the selection of apparatus for this recording must be the frequency response requirements. No exact knowledge on these requirements was available. If the dental use of electromyography is to be scientific and justifiable, one must have such knowledge at hand.

Recording equipment for application in research can be properly selected and used only if the frequency response requirements are accurately known. It is to provide such information or data that this study was performed.

The study was designed to provide information regarding two major problems: the frequency components that are present in electromyographs made in dental situations, and the capabilities (frequencywise) of various recording arrangements.

METHODS

The electromyograms used in this study were made from two of the authors (J.C.H. and J.B.W.), with the five-point generalized reference electrode described in Part I.[1] The active electrode was placed over the area considered to be active in the movement studied (left masseter muscle in closing movements, and the anterior belly of the left digastric muscle in opening movements).

Recordings were made of the voltages appearing at the output terminals of the amplifiers of the Grass Model III-D electroencephalograph. The amplifiers them-

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selves were capable of recording with fidelity from 5 to 600 c.p.s., and with reduced amplitudes to 2,000 c.p.s. These voltages were transferred to magnetic tape with a standard tape recorder capable of recording with fidelity up to 10,000 c.p.s. Thus, the recording system could be depended upon to reproduce every frequency component up to 1,000 c.p.s., with some small loss at 500 to 1,000 c.p.s.

The tapes so recorded were then played into a Kay Electric Company* vibralyzer for spectral analysis. The vibralyzer transfers the voltages fed in to a magnetic recording disk. This disk is then rotated so that each consecutive revolution repeats the playing of the same preselected portion (3 seconds) of the original tape recordings. This same section of the recording is then fed into an amplifying system time after time as the magnetic recording disk revolves. The output of the amplifiers is then passed through bandpass filters (bandwidth selectable to 2 to 200 c.p.s., and center frequency variable from 5 to 4,400 c.p.s.). The filter outputs are then converted to electrical signals. These signals are applied to electrosensitive paper, so that the paper darkens to an extent proportional to the amount of energy passing the filter. The recording paper is mounted on a drum which rotates synchronously with the record disk, and the bandpass filter is shifted in frequency with each rotation. Thus, a record is obtained of frequency versus time, and the density of markings at various frequencies is a measure of the abundance of components at the indicated frequency and occurring at the indicated time.

The vibralyzer can also be used to obtain a more accurate spectrum at some preselected time. This method, called "section" analysis, takes any predetermined 5 millisecond period and uses the intensity of filter output to determine the length of time a multivibrator will oscillate. The multivibrator voltage is used to darken the paper at uniform intensity. Thus, there occurs a line whose location varies with the frequency being scanned and whose length is proportional to the intensity of sound at that frequency (in decibels). This method covers a 35 decibel range of intensities. In effect, the sectional method provides a frequency spectrum.

A large number of recordings were made as described above and were subjected to analysis. However, the findings were uniform, and the results will be described in terms of only two records. These two records were selected because their spectra were the widest encountered (i.e., they represent the maximal frequency response requirements). One of these was a clench movement, made with maximal closing pressure, and the other was an opening movement, made with the mouth opened maximally and held there for several seconds.

RESULTS

Fig. 1. shows the time versus frequency pattern, and the frequency spectra taken at three points in the experiment, for the selected clench movement. It may be seen that a few vibrations at frequencies as high as 600 c.p.s. occur, but these do not appear at sufficient energies to give spectral indications on the sectional records at greater than about 400 c.p.s. The maximal energy content occurs at about 250 c.p.s. (greatest abundance). It is interesting also that the low frequency

*Pine Brook, New Jersey.

components are relatively few. It should be recalled that the section line length is on a decibel scale so that a small decrease in line length may represent a large decrease in energy.

Similar patterns appear in the analysis of the opening movement (Fig. 2.), except that the frequencies encountered do not go above 400 c.p.s. The sections show patterns similar to those of the clench movement except that maximal energies occur at about 150 c.p.s. Thus, the opening movement is quite similar to the clench movement in spectral content, except that the frequencies in the clench are somewhat higher than those in the opening. It is believed that the clench movement selected represents the maximal frequency response requirements encountered in dental electromyography.

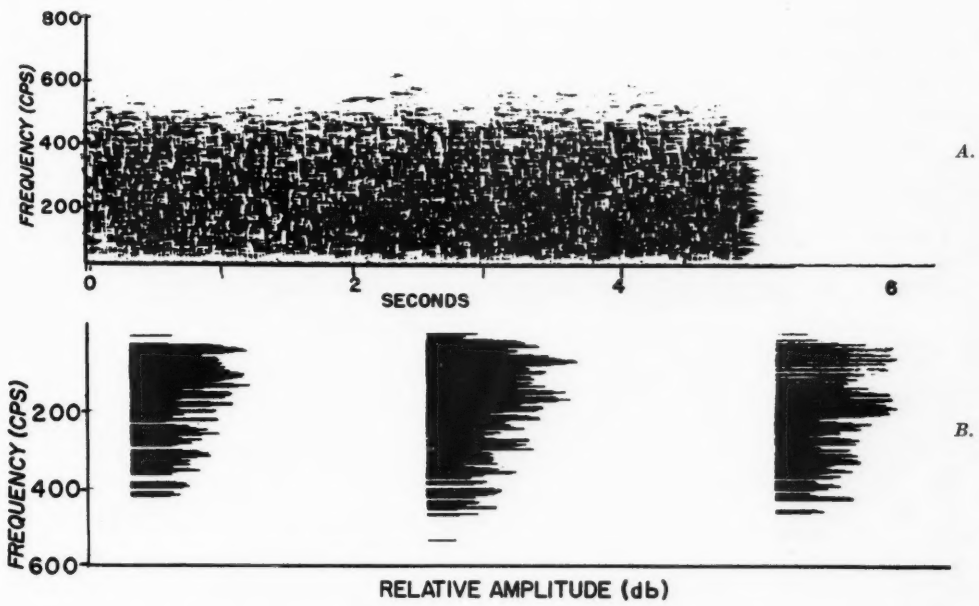

Fig. 1.—*A*, The time versus frequency pattern, and *B*, the frequency spectra from three points of a record made from the left masseter muscle during a clench movement. The frequency range encountered is from very low frequencies to frequencies as high as 600 c.p.s.

DISCUSSION

The electromyographic signals, as they are taken here, are a combination of many spikes originating in a number of motor units. Although the repetition of spikes in a single motor unit may be regular, no such regularity is to be expected in the composite, for the motor units vary in their sequence of firing. At constant tension, however, approximately the same number of motor units will be active at all times. At greater than moderate tensions, most of the motor units will be firing at rates commensurate with development of complete tetanus.

The maximal rate of firing of single motor units is about 100 per second, and with significant quantities of energy in the second, third, and fourth harmonics of the individual impulse, frequencies up to 400 c.p.s. might be encountered even

in activity of a single unit. Add to this the asynchronous nature of multiple unit activity, and it is not surprising that frequencies to 600 c.p.s. are encountered.

There is no way to assess accurately the importance of these higher frequencies in the interpretation of dental electromyograms. It is the goal of every worker in this field to quantitate the activity of the muscles being studied. In view of this desire, one cannot afford to ignore the presence of components he knows to be present.

Therefore, it is highly advisable that, at least at this juncture in our investigations, we record and examine all the energy with which we are faced. High fidelity recording of electromyograms is not difficult, and there is no reason it should not be done.

Besides tape recording, one can also record with high fidelity by utilizing a cathode ray oscilloscope as a voltage indicator, and an oscilloscope camera. The recordings in this case are strips of film, usually 35 mm., with a line (indicating voltage) traced on the film. These records are difficult to analyze, of course, but

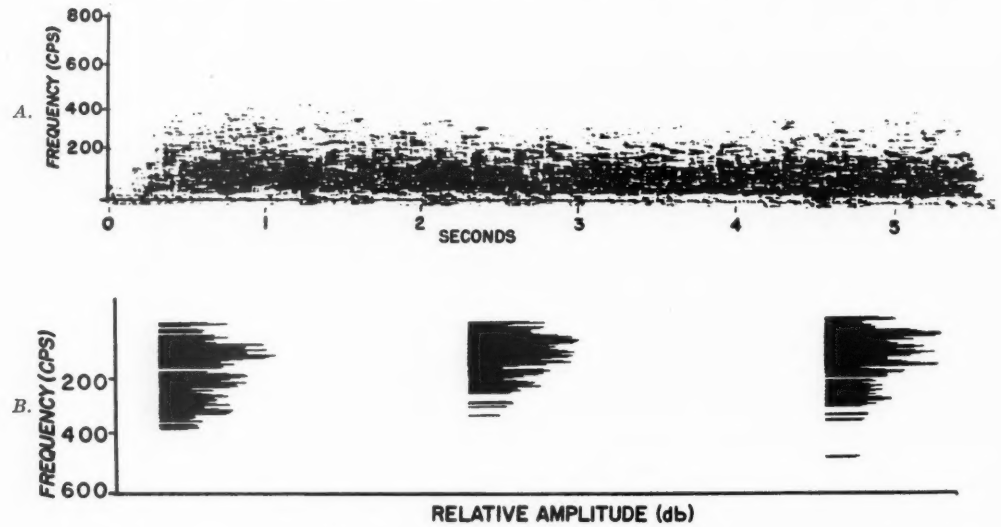

Fig. 2.—*A*, The time versus frequency pattern, and *B*, the frequency spectra from three points of a record made from the left digastric muscle during a maximal opening movement. The frequency range encountered is from very low frequencies to frequencies as high as 400 c.p.s. Note that the frequency patterns are similar to those from the clench movement (Fig. 1) except that the maximal energies occur at about 150 c.p.s.

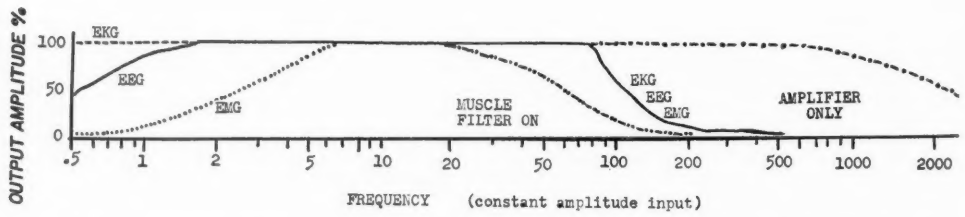

Fig. 3.—Frequency response curves of the Grass Model III-D electroencephalograph, showing curves for amplifier only, amplifier plus penwriter, and amplifier plus penwriter plus muscle filter. (Courtesy Grass Instrument Co., Quincy, Mass.)

could be used for minute inspection should that be desirable. Optical galvanometer oscillographs could also be used, providing the galvanometers selected have a high natural frequency (1,000-2,000 c.p.s.).

In light of the recent development of amplifiers for high-fidelity reproduction of sounds, the selection of amplifiers for electromyography would seem to be no problem. It must be kept in mind that the amplifier sensitivity must be great enough to handle the microvolt signals encountered. Most standard audio amplifiers are quite adequate from the standpoint of frequency response but will require a preamplifier.

The Grass* EEG amplifiers are admirably designed for work of this type. In addition to being sensitive and adequate frequencywise, they are designed for low noise level. However, the pen recorders of the Grass instrument cannot reproduce with fidelity the higher frequencies encountered in electromyography. They will, however, give a fairly representative indication of the amount of electrical activity present because the lower frequencies are present in all muscular contractions. Fig. 3 presents the data provided by the manufacturer for the Grass Model III-D electroencephalograph.

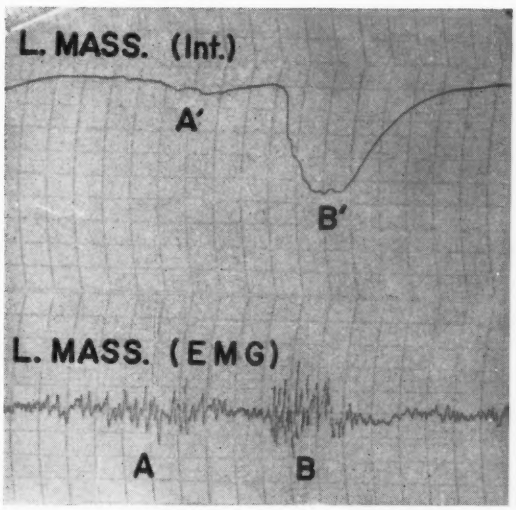

Fig. 4.—Simultaneous records from the same muscle made on a Grass Model 5P3 Polygraph with integration. *A'* is the integrated activity seen at *A*, and *B'* is the integrated activity at *B*. *A* is relatively slow frequency activity which the penmotor can accurately follow. *B* is higher frequency activity which cannot be accurately followed by the penmotor but is accurately recorded at *B'* with integration.

The factor limiting the frequency response of ink-writing recorders is, of course, the mass of the penmotor. The electrical circuitry preceding the penmotor is capable of handling much higher frequencies. The experiments described herein indicate the presence of frequency components beyond the upper limits of pen recording.

When an electrical integrator is used, the summation potentials are of low frequency, and the penmotor can follow them with good fidelity. Therefore, it is

*Grass Instrument Co., Quincy, Mass.

believed that the integrator provides more accurate information than does straight recording. An example of the differences noted is shown in Fig. 4.

In the light of the present findings and analyses, we believe it is in order to recommend the apparatus arrangement shown in Fig. 5 for a complete electromyographic recording system for dental research. For obvious reasons, this recommendation will not include specific designations for components. Each worker must satisfy himself that the components he selects are adequate for the task at hand.

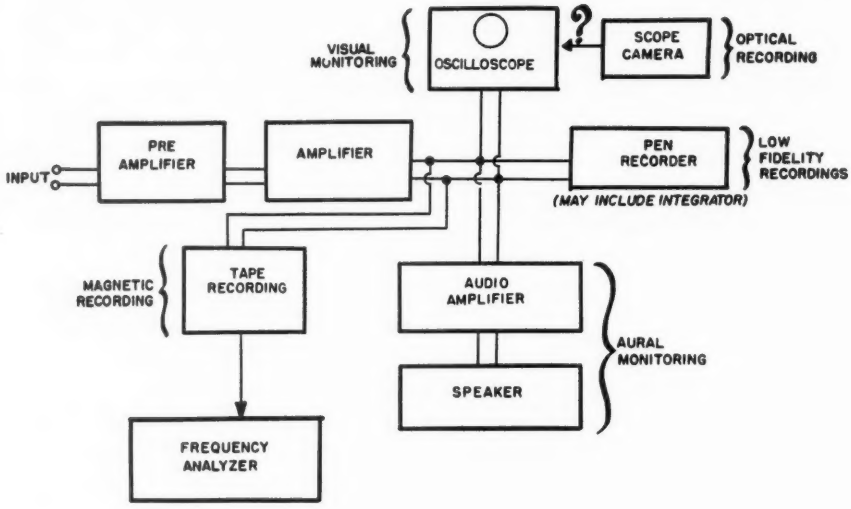

Fig. 5.—A suggested apparatus arrangement for a complete electromyographic recording system for dental research.

SUMMARY AND CONCLUSIONS

A study has been made of the frequencies encountered in dental electromyography, using spectral analysis of tracings recorded with equipment of adequate fidelity.

The highest frequencies encountered were 600 c.p.s., while most of the energy was in the range 100 to 400 c.p.s.

Although pen recording can give valuable information and be of great use in certain instances, it is not considered adequate in itself for all dental electromyography. It is recommended that pen recording be supplemented with integration, optical, and magnetic means and that spectral analysis be a part of the general procedure.

The help of Dr. Donald Borror, Associate Professor, Zoology and Entomology, Ohio State University, in the use of the vibralyzer is appreciated.

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GLOSSARY
OF TERMS USED IN
PLASTICS ARTS

COMPILED BY
H. M. VERNON

FIRST EDITION

St. Louis

THE JOURNAL OF PROSTHETIC DENTISTRY
THE C. V. MOSBY COMPANY
1958

PREFACE

IN PRESENTING THIS GLOSSARY to the dental profession no claim is made by the compiler for originality. He has consulted a number of glossaries and chemical dictionaries and has included only those terms likely to be encountered by dentists, dental technicians, and others serving the dental profession. He has followed closely the glossary published by Plastics Catalogue Corporation, Bristol, Conn., in the Modern Plastics Encyclopedia [Vol. 34, Number 1A, pages 13-24, 1956], since that work is considered authoratative in the plastics industry. In some cases the definitions are verbatim quotations.

The compiler wishes to thank Mr. Willard F. Bartoe and Mrs. Naomi Steck of the physical research laboratories of Rohm & Haas, Inc. for corrections and valuable suggestions.

H. M. VERNON

A

a-stage resin An early stage in the reaction of thermosetting resins, in which they are soluble and fusible.

accelerator A substance that hastens a reaction—a promotor.

acrylates Esters of acrylic acid and various alcohols, such as methyl acrylate, ethyl acrylate. The acrylate resins are not used in the pure state in dentistry but are sometimes used as copolymers with methylmethacrylate.

acrylic When defining a resin. Any of the numerous resins or plastic materials made from acrylic acid or its derivatives. The definition covers acrylates, methacrylates, acrylonitriles, and their copolymers and combinations.

acrylonitrile-vinyl cyanide An acrylic compound used largely as a component in synthetic rubber. It is also used as the principal component of some synthetic fibers. It has been added to styrene to increase the heat and chemical resistance.

alloy (resinous) A composite blend of polymers frequently made by compounding on hot rolls or in extruding machines.

ambient temperature The surrounding temperature. In polymerizing a monomeric substance the ambient temperature may be maintained at some fixed point, while the temperature of the compound being polymerized may be much higher due to an exothermic reaction.

A.S.T.M. Initial letters for American Society for Testing Materials. A.S.T.M. test methods are the accepted standards for most materials.

amines A group of organic chemicals derived from ammonia.

amorphous Not having definite crystalline structure; literally shapeless.

atom A chemical unit. The smallest part of an element which remains unchanged during any chemical reaction and is thus indivisible and indestructible. The building blocks of molecules.

atomic weight The relative weight of an atom of any element as compared with an atom of oxygen taken as 16.

B

b-stage resin An intermediate stage of reaction in thermoset resins where they soften when heated and swell when in contact with liquids, but do not entirely fuse or dissolve.

blanching Postmolding whitening of plastic surfaces, also referred to as *chalking*. It may be general or localized. It is usually superficial.

bleed To give up color by transfer to adjacent materials either solid or liquid. To lose plasticizer or mold lubricant in the same manner.

blending Mechanical mixing of two or more ingredients of a molding composition to insure proper distribution of component parts. Most of the better class of acrylic resin powders used in dental work are blends of several types of polymers.

bubble A void usually spherical containing air or other gas in a molded or cast plastic article. Often the result of improper heating, insufficient pressure, or both.

C

C-stage resin Thermosetting resins in final stage of reaction. They are insoluble and infusible. Articles molded of phenolic resins are in this stage.

cast resins Liquid resins poured in molds and hardened therein without the application of external pressure.

catalyst A substance which initiates a chemical reaction without entering into the chemical compound formed. Most catalysts used in the plastics are organic peroxides, such as benzoyl peroxide.

cellulose A carbohydrate derived from the inert woody fiber of plants. The skeletal framework of plant cells. It is the basis of several plastic materials.

cellulose resins A large family of resins of which cellulose nitrate, cellulose acetate, ethyl cellulose, and cellulose acetate-butryate are representative members. Cellulose resins have been at times used for dentures without success.

chalking Dry chalklike appearance or deposit on the surface of a plastic.

chemically pure, C. P. Indicates the highest reagent quality suitable for analytical work because of its freedom from impurities.

coefficient A numerical factor by which the value of one quantity is multiplied to give the value of another.

C. of linear expansion (thermal) A number indicating the expansion of a substance for specified temperature increase. (Either °C. or °F.)

cold cure Term used in dental arts to describe resins which are hardened at relatively low temperatures, usually by a redox reaction.

cold flow Change of dimension caused by sustained application of a force on a material at temperatures lower than the material softening point.

colloid A suspension or dispersion of a substance in a liquid. Colloids are not solutions. They do not settle out. Gelatine in water and alginate and water mixtures are typical colloids.

condensation A chemical reaction in which two or more molecules combine with the separation of water or some other simple substance. (Modern Plastics Encyclopedia for 1956.) It differs from polymerization in that in the latter there is no change in the number of atoms of any element present in the molecule.

condensate resins Resins which involve a chemical reaction of condensation. Among the condensate resins are phenol-formaldehyde, the alkyds, and urea-formaldehyde.

cope The upper half of a flask in the casting art, and hence applicable to the upper or cavity side of a denture flask.

copolymer A polymer built from two or more monomers. Copolymers are not mixtures or blends of separate polymers, nor the result of the action of a monomer on a chemically differing polymer.

cracking A method of recovery or alteration. In the case of synthetic resins the term is applied to a method of reclaiming monomer from scrap polymer.

crazing Fine cracks on the surface or within a plastic article.

creep (See *cold flow*)

cross link To tie linear molecules together by the addition of a polyfunctional monomer or other agent which imparts some degree of three-dimensional stability (thermoset property) to the polymerized result.

cure To change the properties of a plastic or resin by chemical reaction, which, for example, may be condensation, polymerization, or addition; usually accomplished by the action of either heat or catalyst or both, and with or without pressure.

D

degradation Loss of some property as a result of a change within the material.

density Weight per unit volume—usually expressed as grams per cubic centimeter. The term is often loosely used to denote solidity or lack of porosity.

depolymerization The conversion by chemical or physical means of a polymer into a monomer. Depolymerization of polymethyl-methacrylate or polystyrene can be effected by heating. Surface depolymerization often occurs as a result of severe mechanical stressing in polishing.

dimensional stability Ability of a molded article such as a denture to retain the precise shape in which it was molded.

discoloration Any change from the initial color of a plastic article whether brought about by action of external agents such as chemicals, heat, light, or chemical change inherent in the composition.

dough Descriptive term for the aggregate resulting when acrylic resin monomers and polymers are mixed.

dough stage The soft nontacky stage of an acrylic resin mix when all the liquid has been absorbed by the powder, and the mix can be packed without adhering to the mixing jar or instruments used for handling. The correct packing stage.

drag The lower or model side of a denture flask.

E

elastic deformation Deformation of a substance under stress which is recovered after removal of the stress.

elastic limit The extent to which a material may be strained (deformed) and still completely recover after removal of the straining force.

elastic memory The tendency of a compression on molded, formed, or injection-molded polymer to return to its premolded shape due to strain relaxation when heated or otherwise subjected to influences which tend to cause softening. Also called *strain relaxation.*

elastomer A generic term for natural or synthetic materials having the properties of elastic rubber.

emulsion A suspension of fine particles or droplets of one material in a liquid, only obtainable when the materials are not mutually soluble.

emulsion polymerization, emulsion suspension Polymerization of monomers suspended in a liquid medium. Practically all the acrylic resin powders used in dentistry are produced by emulsion polymerization in water.

ester Chemical compound resulting from the reaction of an organic acid and an alcohol. Acrylic monomers are esters of acrylic or methacrylic acid and various alcohols.

ethanol Ethyl alcohol whether derived from grain, fruits, molasses, or other sources.

exothermic reaction A reaction in which heat is liberated. It often proceeds rapidly, sometimes explosively. Polymerization of monomers is usually an exothermic reaction.

extrusion Working preplasticised material in a chamber and forcing it out through an orifice which shapes it in the form of rods, tubes, or other shapes.

F

fabricate To work materials into final shape.

filler An inert material added to a plastic composition, usually to impart certain properties to a finished article.

fin A defect in a molded denture due to a crack or fissure.

flamability Measure of the extent to which a material will support combustion. (Modern Plastics Encyclopedia for 1956.)

flash Excess of plastic material forced out between the halves of a flask during closure.

flash mold A mold designed in such a way as to permit excess material to escape during closure. The typical dental flask is a good example of a flash mold.

flexural strength A measure of the ability of a material to withstand failure by bending.

form (v) To apply force to a plastic material with intention of making it flow, bend, or otherwise conform to a given shape. The plastic material is usually a heated sheet or a preform (blank) of a polymerized product.

fusion The operation of liquefying or combining materials by heating.

G

gel A somewhat rigid two phase liquid-solid system in which the solid phase is surrounded and supported by the liquid phase.

gelation The formation of a gel.

gel-strength The ability of a gel to flow under pressure without breaking. A measure of tenacity under molding stresses.

H

haze A cloudy appearance of transparent platsics. It can be internal or external. In the latter case it is not the same as chalking.

heat distortion temperature The temperature at which a plastic bar will be deflected under a bending load. (See A.S.T.M. Method D648-45T for details of test.)

hue A property of color; the principal distinguishing color, such as red, blue, yellow; other properties of color are chroma or saturation—the intensity of hue; value or brightness—the amount of white or black.

hydrolysis A chemical reaction caused by water.

hygroscopic Tending to absorb water.

I

impact resistance Resistance of materials to fracture by shock. Two types of tests are used; the Charpy, in which the specimen is supported at both ends, and the impact force is delivered in the center of the specimen; the Izod, in which the specimen is supported at one end only, and the impact force is delivered at the other. In both tests the force is delivered by a pendulum, and the residual energy of the pendulum is measured after it has performed its work.

index of refraction (See *refractive index)*

inhibitor A chemical agent added to a monomer to prevent spontaneous polymerization. The most frequently used inhibitor for acrylic monomers is hydroquinone.

injection molding A molding procedure whereby a heat-softened plastic material is forced from a cylinder into a relatively cold cavity which gives the article the desired shape. (Modern Plastics Encyclopedia for 1956.) (See *transfer molding)*

K

ketone A group of hydrocarbon compounds. Acetone is a ketone.

kickover During the change from a monomer to a polymer a stage is reached at which a rapid evolution of heat occurs; this is called the kickover.

L

lastic A synthetic material which at a certain temperature exhibits the physical properties of rubber. It may be prepared by chemical action, polymerization, or formulation.

leach To extract a soluble substance from one less soluble.

linear molecule A macromolecule extending essentially in one dimension, namely, length. The type of molecule which makes up most thermoplastic resins.

M

macromolecule From the Greek—*macros*—broad; a large molecule. The polymer molecule is often referred to as a macromolecule.

methanol Methyl alcohol, whether derived from the destructive distillation of wood, or from other sources, such as organic synthesis.

migration Transfer of one part of a resinous material to another part. Plasticizers, organic colors, solvents, and unpolymerized monomer all tend to migrate under certain conditions. (See *bleed*)

modulus of elasticity The ratio of unit stress to unit strain. (Modern Plastics Encyclopedia for (1956).

mold shrinkage The immediate shrinkage a molded article undergoes when removed from the mold and cooled to room temperature.

molding powder Plastic material in a comminuted form prepared with or without colors, plasticizers, mold lubricants, fillers, etc., for use in the molding art.

molecule Chemical combination of two or more atoms. The smallest quantity of matter that can exist in the free state and retain all the properties of its original substance. All the molecules of all compounds contain two or more atoms. The molecule of water H-O-H or H_2O consists of two atoms of hydrogen and one atom of oxygen.

molecular weight The relative mass of a molecule in relation to that of a hydrogen atom.

monomer Mono = single, mer = part. The simplest structural unit of a polymer molecule. The term is applied to the monomeric form of a polymerizable chemical. In dentistry, it usually refers to the monomeric form of methyl methacrylate.

O

opacifier An additive which makes a transparent substance more or less opaque.

orange peel Surface roughness somewhat resembling that of the peel of an orange. Often encountered on the surface of dentures and other resin prostheses which have been strongly heated or subjected to solvent effects. This is especially true of the highly plasticized varieties.

organosol Dispersion of a resin in a liquid. The solid phase is usually a vinyl resin; the liquid phase is nonaqueous and contains volatile liquids. Organosols are applied by spraying, dipping, brushing, or slush molding, and the resin is set by drying and fusion.

P

parting agent A separating agent applied to the surface of a mold cavity to prevent the molded article from sticking to the mold, and to prevent in some cases the introduction of moisture or other contaminating agents from the mold material.

pigment A finely powdered insoluble material used to impart color, opacity, whiteness, or blackness to a material such as a plastic.

plastic (adj.) Capable of being shaped into an essentially permanent form. Made of any of the plastic materials.

plastic (noun) A plastic is any one of a large and varied group of materials which consists of, or contains as an essential ingredient, a substance of high molecular weight, and which, while solid in the finished state, at some stage in its manufacture is soft enough to be formed

(cast, calandered, extruded, molded, etc.) into shape by flow—usually through the application singly or together of heat and pressure. (Modern Plastics Encyclopedia for 1956.)

plasticity Property of solids which permits them to be made to take and retain the form of a mold.

plasticize To make a material plastic or moldable, usually by the addition of a compatible plasticizer. May also be used to refer to the effect of heat on plastics.

plasticizer A material incorporated in a plastic to increase its workability and its flexibility or distensibility. (A.S.T.M.) Plasticizers are usually oily substances of high boiling points which do not enter into the polymer chains, but contribute their softening effect by acting as a lubricant between the polymer molecules.

plastigel A plastisol containing a gelling agent added to obtain certain properties of flow.

plastisol A mixture of resin and plasticizer, moldable by compression injection or casting, and convertible by heating to some degree of solidity. Most plastisols are compounded of vinyl polymers or copolymers and plasticizers, fillers, and pigments and, when processed, have elastomeric properties.

poly Prefix from the Greek—many. Used in plastics terminology, it indicates polymerized form. Thus, polystyrene, polyethelene, polyvinyl acetate, polymethyl methacrylate, etc.

polymer Poly = many, mer = part. A compound formed by the linking of molecules which have functional groups which permit their combinations to proceed to high molecular weights under suitable conditions. Polymers may be formed by simple addition of chemically unchanged monomer molecules or by condensation in which a chemical change occurs and a reaction product is formed.

polymerization The reaction, either physical or chemical, in which a polymer is formed.

positive mold A mold designed to contain all the charge of molding material and in such a manner that the entire charge is subjected to pressure throughout the molding cycle.

preform (noun) A prepared "blank" such as the celluloid blanks formerly used in dentistry.

preplasticize To heat a molding material to molding consistency in a separate unit before feeding it into a compression mold, transfer mold, or injection cylinder.

Q

qualitative Pertaining to quality or kind as opposed to quantity or amount.

qualitative reaction A reaction to detect the presence of a substance in a mixture of substances but not relative proportion.

quantitative Pertaining to amount or percentage.

quantitative reaction A reaction that determines the amount of a substance in a mixture of substances.

quench To cool suddenly.

R

redox polymerization Polymerization initiated by the chemical reaction between an oxidizing catalyst, such as a peroxide, and a reducing promoter, such as a tertiary amine. Redox polymerization is utilized in the so-called autopolymers used in denture repair materials and in restorative dentistry.

refractive index The ratio of the velocity of light in a medium to the velocity of light in air under the same conditions.

resinoid Any of the thermosetting resins either in the initial fusible state or in the final infusible state.

S

semipositive mold A mold which allows for the escape of some excess during the closing. A flash mold. The typical denture mold is a semipositive mold.

set To solidify, gel, or harden by chemical or physical action.

set-up To harden.

shelf life Storage life.

sink mark Sunken imperfection in a molded article indicating local separation from the mold walls. It may be the result of localized contraction, or it may be due to the evolution of gas, or to imperfect mold filling. Sink marks are sometimes called "lakes."

slurry A pourable mixture of a liquid and an undissolved solid. A wet mix of monomer and polymer in a pourable state. Pourable mixes of dental stone or plaster are slurries.

sol A colloidal solution, such as a dispersion of a polymer in a liquid monomer, or other solvent.

solution Homogenous mixture of two or more substances such as a gas in a liquid, a liquid in a liquid, or a solid in a liquid.

solvent Any substance, usually a liquid, which dissolves another substance.

strain A deformation—change of size or shape resulting from stress.

stress The force that produces or tends to produce strain. Stresses can be internal or external, and change of form (strain) can result from either.

synthesis The production of complex compounds by chemical processes, by reactions involving elements and simpler compounds. In some syntheses naturally occurring substances are produced artificially, such as rubber, indigo, quinine, and many other substances originally derived from natural sources.

T

tack A property of adhesive substances referring to their tendency to adhere to themselves or other things.

tensile strength Measure of the load necessary to break a material by direct pull. Usually given in pounds per square inch or in kilograms per square centimeter.

thermal conductivity A measure of the ability of a material to conduct heat.

thermoplastic resin A resin which is capable of being heat-softened and molded, which, when cool, retains the shape given it by the molding operation. A thermoplastic resin can be reheated and remolded. Most of the resins used in denture construction are thermoplastic resins.

thermoset resin A resin moldable by heat only when in a semipolymerized condition. After complete polymerization the thermoset resins cannot be remolded. The phenolic resins are examples of thermoset resins.

thixotrophy The property shown by certain gels which are solid at rest, but liquefy on agitation.

transfer molding A method of molding thermosetting materials in which the plastic is first softened by heat and pressure in a transfer chamber then transferred through suitable sprues, runners, and gates into a closed mold for final curing. (Modern Plastics Encyclopedia of 1956.)

U

U.S.P. Tested to conform to the requirements of the United States Pharmacopoeia.

V

viscosity A measure of the resistance of a liquid to flow.

W

warp Dimensional distortion in a plastic object after molding. (Modern Plastics Encyclopedia for 1956.) Warpage is not to be confused with thermal contraction nor the size change due to polymerization contraction. In dentures it is frequently the result of incomplete polymerization and subsequent relaxation of stresses. It may also be due to the presence of nonpolymerizable materials such as organic plasticizers.

P.O. Box 1587
Pittsburgh 30, Pa.

BOOK REVIEWS

INTRODUCTION TO DENTAL ANATOMY. By James Henderson Scott, D.Sc., M.D., L.D.S., and Norman Barrington Bray Symons, M.Sc., B.D.S. Edinburgh and London, 1958, E. & S. Livingstone Ltd., The Williams & Wilkins Co., Baltimore, exclusive U. S. agents. 344 pages, 219 illustrations, indexed. Price $8.50.

The first chapter of this book deals briefly with the surface and root canal form of the teeth, including some information about racial differences in tooth form. There follows a good description of the embryonic development of the face and oral cavity and the embryonic development of the teeth. Two chapters of the book deal with the growth and development of the face and jaws, and two chapters with the establishment of the deciduous and permanent dentition and tooth movements. The illustrations in the chapter on the dental development at different ages are a series of very fine roentgenograms of the jaws at intervals between birth and adult life. Seven chapters of the book treat with a description of the microscopic structure of oral tissues: enamel, dentine, cement, pulp, periodontal membrane, and oral mucosa. There are also chapters concerning the anatomy and function of the temporomandibular joint and age changes in the teeth and jaws. The last one-fourth of the book is an unusually good discussion of the evolution and comparative anatomy of the dentition from elasmobranchs to primates.

The authors have done good work in concise and clear coverage of a wide scope of material. The book is easy to read. The illustrations are all good, and some of them are superior.

Although the format is not sufficiently interesting to attract immediate attention, it is an excellent piece of work, and it should prove to be of very real value, both for teaching and for general reference, to those who give it a careful examination.

Dorothy Permar

SEVENTH ANNUAL ESSAY CONTEST

SPONSORED BY

THE AMERICAN DENTURE SOCIETY

Prizes will be awarded to the two senior dental students who submit the best essays on some phase of prosthetic dentistry in the seventh annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

RULES

1. The contest is open to all senior dental students of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college conduct its own contest to determine the two best essays submitted by members of its senior class.)
3. Essays are to be on some phase of prosthetic dentistry and limited to a maximum of 3,000 words. The following topics are suggested:
   (a) Centric Relation and the Interocclusal Distance,
   (b) Registration of Mandibular Movements in the Construction of Complete Dentures,
   (c) Esthetics,
   (d) Diagnosis and Treatment for a Patient Requiring Unusual Prosthetic Services.
4. Essays must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY and must be prepared in a form which is satisfactory to the requirements of that JOURNAL.
5. The original essay and one copy must be submitted for the use of the judges.
6. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. Paragraphs must be indicated clearly by indentations, and generous margins must be allowed on each page.
7. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTY, if they are used. Only good glossy black and white photographic prints, or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the figure number and the legend typed on the paper beneath the illustration.
8. The form and punctuation of references must conform to the style used in the JOURNAL OF PROSTHETIC DENTISTRY. The references must be keyed to the text material.
9. The permanent address of the author must be at the end of the reference page.
10. The student has a free range in the choice of topics within the broad interpretation of prosthetic dentistry.
11. Essays will be judged on the basis of subject matter, neatness, composition, spelling, illustrations, charts and tables, number and accuracy of references, continuity of thought, and length of the essay.
12. The judges of the contest are members of a committee of The American Denture Society. The decision of the judges is final.
13. Essays are to become the property of The American Denture Society. None will be returned.
14. All essays submitted to the contest shall be clearly marked "Contest Essay" and shall be accompanied by a letter from the professor of prosthetic dentistry and/or the dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
15. Essays must be postmarked on or before July 15, 1959 and sent to:

    Dr. Victor L. Steffel
    Secretary, The American Denture Society
    College of Dentistry, The Ohio State University
    Columbus 10, Ohio

NEWS AND NOTES

MEETINGS

Greater New York Academy of Prosthodontics, School of Dental and Oral Surgery, Columbia University, New York, N. Y., Dec. 6 and 7, 1958.

Greater New York Dental Meeting, Statler Hotel, New York, N. Y., Dec. 8 to 12, 1958.

The Northeastern Association of Dental Editors is sponsoring its Second Annual Dental Writing Conference on Friday, Dec. 12, 1958, at the New York Academy of Sciences, 2 East 63rd St., New York, N.Y. For further information, write to Dr. Bruce L. Douglas, Chairman, 93-08 Queens Blvd., Rego Park 74, N. Y.

American Denture Society, Congress Hotel, Chicago, Ill., Feb. 6 and 7, 1959.

American Academy of Restorative Dentistry, Conrad-Hilton Hotel, Chicago, Ill., Feb. 7 and 8, 1959.

American Academy of Crown and Bridge Prosthodontics, Conrad-Hilton Hotel, Chicago, Ill., Feb. 7 and 8, 1959.

Fifteenth Australian Dental Congress, Adelaide, South Australia, Feb. 23 to 27, 1959. For further information, write to the Secretary, Fifteenth Australian Dental Congress, 51 Grenfell St., Adelaide, South Australia.

Southeastern Academy of Prosthodontics, Atlanta Biltmore Hotel, Atlanta, Ga., March 13 to 15, 1958.

Academy of Denture Prosthetics, Sheraton-Seelback Hotel, Louisville, Ky., April 12 to 17, 1959.

American Association for Cleft Palate Rehabilitation, Sheraton Hotel, Philadelphia, Pa., April 30 to May 2, 1959.

ANNOUNCEMENTS

Reprints of the "Glossary of Prosthodontic Terms" may be obtained by writing to Glossary Reprints, 400 Starks Bldg., Louisville, Ky. The price is fifty cents per copy. Please make your check or money order payable to Glossary Reprints and enclose with your order.

Northwestern University Dental School announces the following postgraduate courses:

Clinical Features of Oral Lesions, Dec. 1 to 3, 1958.
Current Concepts in Operative Dentistry, Dec. 1 to 3, 1958.
Basic Oral Surgery, Feb. 2 to 6, 1959.
Newer Concepts in Periodontics, Feb. 2 to 6, 1959.
Use of Gold Foil, Feb. 2 and 3, 1959.
Endodontics, Feb. 25 to 27, 1959.
Major Oral Surgery—A, March 2 to 13, 1959.
Intermediate Oral Surgery, March 16 to 20, 1959.
Complete Denture Procedures, March 30 to April 2, 1959.
Major Oral Surgery—B, April 6 to 10, 1959.
Prosthetic and Orthodontic Rehabilitation for the Cleft Palate Patient, April 6 and 7, 1959.
High Speed Instrumentation, April 15 and 16, 1959.
Pedodontics, April 15 and 16, 1959.
Use of Drugs in Dental Practice, April 29 to May 1, 1959.
Diagnosis, Roentgenography, and Treatment Planning, May 4 and 5, 1959.
Pedodontic Teachers' Conference, June 8 and 9, 1959.

For further information and application, write to Director of Dental Postgraduate Study, Northwestern University Dental School, 311 E. Chicago Ave., Chicago 11, Ill.

University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Dentistry for Handicapped Children, Dec. 1 to 3, 1958.
Periodontal Therapy, Dec. 15 to 19, 1958.
Complete Denture Prosthesis, Jan. 12 to 15, 1959.
Prosthetic Relations of the Temporomandibular Joint, Jan. 19 to 23, 1959.
Hospital Dentistry, Jan. 26 to 28, 1959.
Mandibular Third Molar, Feb. 9 to 13, 1959.
Oral Diagnosis and Roentgenology, Feb. 16 to 20, 1959.
Periodontal Prosthesis, Feb. 16 to 20, 1959.
Partial Dentures, Feb. 23 to 27, 1959.
Occluso-Rehabilitation, March 2 to 6, 1959.
Principles of Occlusion, March 4 to 6, 1959.
Oral Medicine, March 9 to 13, 1959.
Cephalometry, March 9 to 11, 1959.
Applied Anatomy, March 16 to 18, 1959.
Extraoral Tracers in Rehabilitation of Function, March 16 to 18, 1959.
Pulp Reactions, April 2 and 3, 1959.
Minor Tooth Movement, April 8 to 10, 1959.
Tenth Mid-Atlantic States Conference in Dentistry, April 12 to 17, 1959.
Endodontics, April 13 to 24, 1959.
Clinical Occlusion, April 20 to 24, 1959.
Complete Dentures, April 27 to May 1, 1959.
Newer Concepts in Oral Rehabilitation, May 4 to 8, 1959.
Refresher Course in Periodontal Therapy, May 9, 1959.
Advanced Periodontal Therapy, May 11 to 15, 1959.
Complete Denture Seminar, May 14, 1959.
Complete Denture Prosthesis, May 18 to 22, 1959.
The Use of High Speed Instruments and Equipment, May 20 and 21, 1959.
Immediate Root Resection, June 1 to 6, 1959.
Twin Wire Mechanism, June 1 to 5, 1959.

For further information and application, write to Director, Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce Street, Philadelphia 4, Pa.

Western Reserve University, School of Dentistry, announces the following postgraduate courses:

Periodontal Prosthesis, Jan. 3 to 5, 1959.
Psychodynamics and Practice Administration, March 30 through April 1, 1959.

For further information and application, write to Director of Postgraduate Education, School of Dentistry, Western Reserve University, Cleveland 6, Ohio.

The Prosthetic Section of the Department of Stomatology, Division of Graduate Studies, School of Medicine, Boston University announces the following postgraduate courses:

Partial Denture Prosthesis, Jan. 8 to 10, 1959.
Full Denture Prosthesis, Jan. 12 to 16, 1959.
Oral Pathology (for oral surgeons), Jan. 12 to 16, 1959.

For further information and application, write to the Department of Stomatology, Division of Graduate Studies, School of Medicine, Office of the Dean, Boston University, 80 East Concord Street, Boston 18, Mass.

The New York University, College of Dentistry, announces the following postgraduate courses:

Refresher Course in Periodontics and Oral Medicine, Feb. 11 to April 22, 1959 (Wednesdays, 4:00 to 6:00 P.M.).
Periodontics and Oral Medicine in the Spanish Language, March 2 to March 27, 1959.

For further information and application, write to Dr. Sidney Sorrin, Department of Periodontia and Oral Medicine, New York University, College of Dentistry, 421 First Ave. (corner 25th St.), New York 10, N. Y.

Temple University School of Dentistry announces the following graduate and postgraduate courses:

Fixed Prosthesis—Advanced, Jan. 7, 14, 21, 28, Feb. 4, 11, 25, March 18, 25, 1959.
Clinical Oral Pathology, Jan. 15 to 17, 1959.
Advanced Orthodontics, Jan. 18 to 31, 1959.
Radiodontics—Advanced, Jan. 22 to 24, 1959.
Head and Neck Dissection, Feb. 4 through June 10, 1959.
Periodontal Prosthesis, Feb. 16 to 20, 1959.
Practice Administration, Feb. 28, 1959.
Time, Motion, and Speed, March 1 to 3, 1959.
Oral Medicine for General Practitioner, March 9 to 13, 1959.
Gnathology and Oral Rehabilitation, March 9 to 14, 1959.
Electronic Electrosurgery, March 20 and 21, 1959.
Full Denture Prosthesis, April 6 to 11, 1959.
Full Denture Prosthesis—Advanced, April 12 to 18, 1959.
Advanced Surgical Techniques in Periodontal Therapy, April 18 to 22, 1959.
Transographics in Full Mouth Restoration, May 4 to 9, 1959.
Fundamental Periodontics, June 1 to 5, 1959.
Immediate Root Resection, June 1 to 6, 1959.

For further information and application, write to Postgraduate Division, Temple University School of Dentistry, 3223 North Broad St., Philadelphia 40, Pa.

The University of Washington, School of Dentistry, announces a course of graduate study in Periodontics. The course is of eighteen months' duration.

For further information and application, write to Dr. Saul Schluger, Director, Graduate Dental Education, University of Washington, School of Dentistry, Seattle 5, Wash.

Tufts University School of Dental Medicine announces the following postgraduate refresher courses:

Cephalographics and Diagnosis, Jan. 14 to 16, 1959.
Crown and Bridge Prosthesis Participation Course, Jan. 30, 31, Feb. 6, 7, 13, 14, 21, 28, 1959.
Orthodontic Principles of Interest to the General Practitioner, Feb. 4 through March 25, 1959 (Wednesdays).

Oral Pathology for the Oral Surgeon, Feb. 5 through April 2, 1959 (Thursday afternoons).
Occlusal Equilibration, Feb. 9 to 11, 1959.
Local Anesthesia, Feb. 9 to 11, 1959.
Minor Oral Surgery, March 4 to April 22, 1959 (Wednesdays).
Occlusal Adjustment, March 30 to April 1, 1959.
Full Denture Implants, April 6 to 10, 1959.
A Special Participation Course in Periodontology, April 13 to 17, 1959.
Occluso-Rehabilitation I, April 20 to 24, 1959.
Oral Roentgenology, April 22, 1959.
Full Denture Prosthesis, June 1 to 5, 1959.
Clinical Dentistry for Children, June 15 and 16, 1959.

For further information and application, write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

Evaluation of Newer Operative Methods, Jan. 23 and 24, 1959.
Crown and Bridge Prosthodontics, Jan. 26 to 30, 1959.
Complete Denture Prosthodontics, Feb. 16 to 20, 1959.
Partial Denture Prosthodontics, Feb. 23 to 27, 1959.
Endodontics, March 2 to 6, 1959.
Pedodontics, March 9 to 13, 1959.
General Anesthesia, April 20 to 24, 1959.
Dental Drugs in Action, May 1 and 2, 1959.
Periodontics, May 4 to 8, 1959.

For further information and application, write to Postgraduate Division, College of Dentistry, The Ohio State University, Columbus 10, Ohio.

The Rowe Smith Memorial Foundation announces the Fifth Annual Seminar at Fly-N-Fish Lodge on Caddo Lake, Karnack, Texas, Jan. 18 to 21, 1959. The subject of this seminar will be "The Blood and Bleeding." For further information, write to the Rowe Smith Memorial Foundation, Inc., 501 State National Bank Bldg., Texarkana, Ark.

The Greater Miami Chapter of Alpha Omega announces the Sunland Seminar on "A Total Periodontal Concept," Jan. 25 to 29, 1959 at the Deauville Hotel, Miami Beach, Fla.

For further information and reservations, write to Dr. Irving Gordan, 420 Lincoln Rd., Miami Beach, Fla.

The Postgraduate Division of the Prosthetic Department of New York University, College of Dentistry, is tendering a reception and dinner in honor of Dr. Joseph S. Landa on Thursday evening, Jan. 22, 1959 at the Belmont Plaza Hotel, New York, N. Y.

For further information, write to Dr. Sidney I. Silverman, Chairman, 80 Park Ave., New York 16, N. Y.

The Nomenclature Committee of the Academy of Denture Prosthetics plans to present recommendations for revision of the Glossary of Prosthodontic Terms (J. PROS. DEN. *6:* Appendix, 1956) to the Academy next April. For that reason, constructive suggestions are again invited. Revisions will involve the addition of terms not included in the original Glossary, deletion of certain obsolete or objectionable terms, and changes in definitions to clarify the meaning of some terms. It is particularly desired that suggestions for new or modified definitions include a proposed definition which is considered to describe clearly the term involved.

Communications should be addressed to the Chairman of the Nomenclature Committee, Dr. Carl O. Boucher, The Ohio State University, College of Dentistry, Columbus 10, Ohio.

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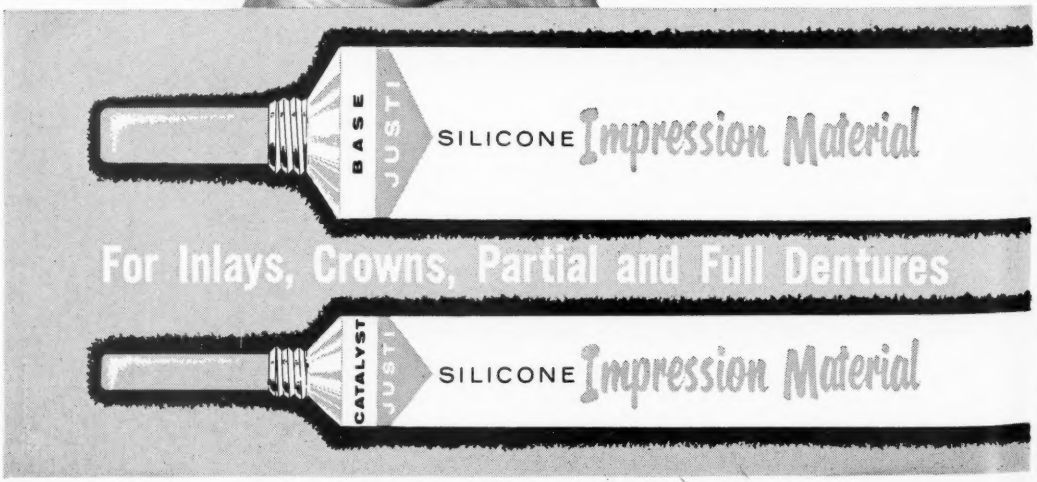
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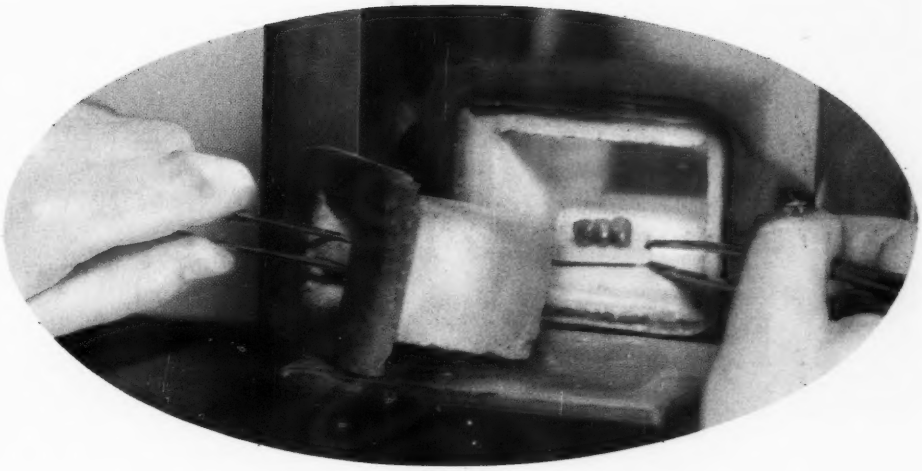

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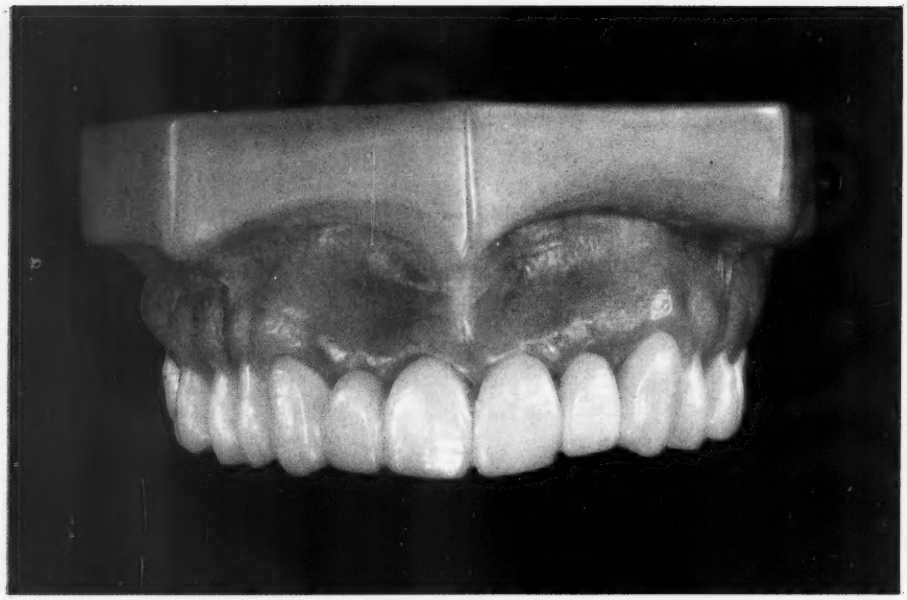

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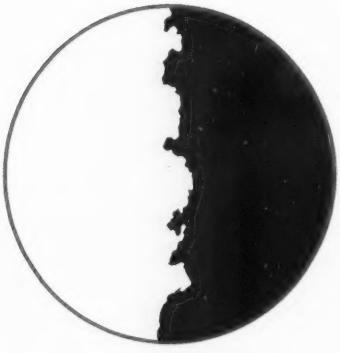

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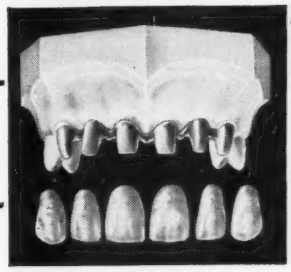

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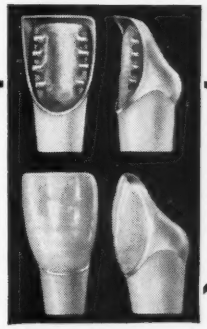

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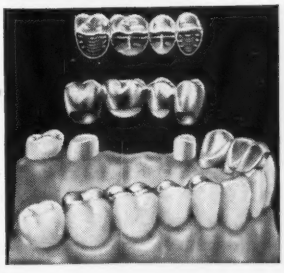

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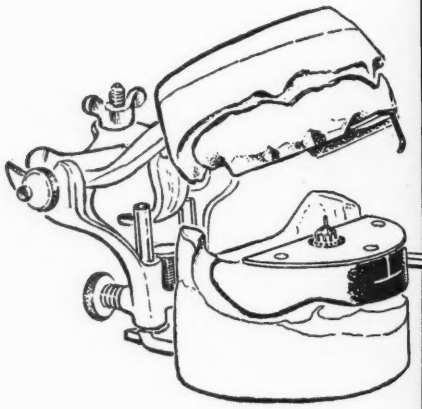

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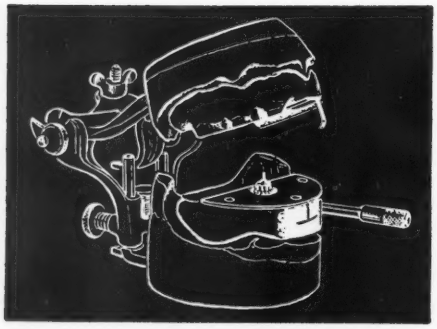

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Shade matching accuracy is always important but in partial dentures it is critical. A development project was set up to further advance the present superiority of Dura-Blend plastic teeth in this respect.

The first step was to make a master shade guide composed of all the principal tooth shades available. Patients were examined for closest match possible with this master shade guide. It was demonstrated that by the addition of three new shades, the Dura-Blend shade guide offered first choice for accuracy of match more often than any other — in fact, exceeding by 44% the brand scoring second. These new Dura-Blend shades are composed of one quite bright and light, one similar but darker and one quite grey.

13 New Moulds

The new moulds introduced with Myerson's AEsthetic porcelain teeth successfully combined naturalness with cosmetic effects. To offer the same facility in plastic teeth, ten of the most popular upper anterior forms were chosen to be added to the present beautifully carved and characterized Dura-Blend moulds.

Wider Range Increases Convenience

These moulds also will be useful where the following features are indicated:

1. More subtle labial carvings.
2. Slender forms.
3. Longer ridge lap (see Figure 1).

Four of the new upper moulds are square in outline. Three lower moulds, short in relation to width, have been added to increase convenience.

Tested for Detectability

Naturalness is often claimed for artificial teeth without any proof whatsoever. It was decided to actually *test* Dura-Blend teeth for this very important feature.

Representative Dura-Blend teeth were used in an anterior partial. The surrounding natural teeth were characteristic in appearance of good health and good dental care.

Figure 1. Dura-Blend now offers choice of profile (A) Characteristic of new moulds; (B) Typical of many existing moulds.

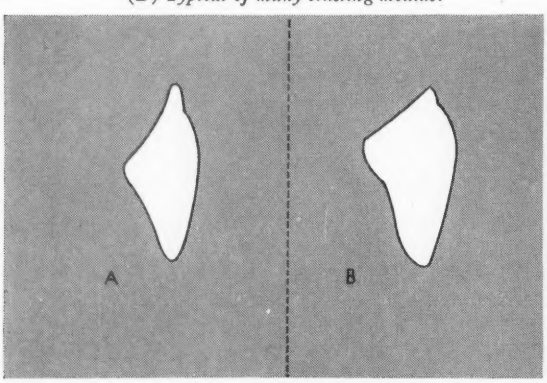
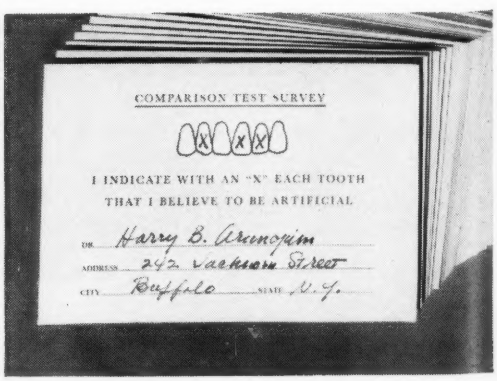


Figure 2. Forms used to record dentists' choices in detectability test.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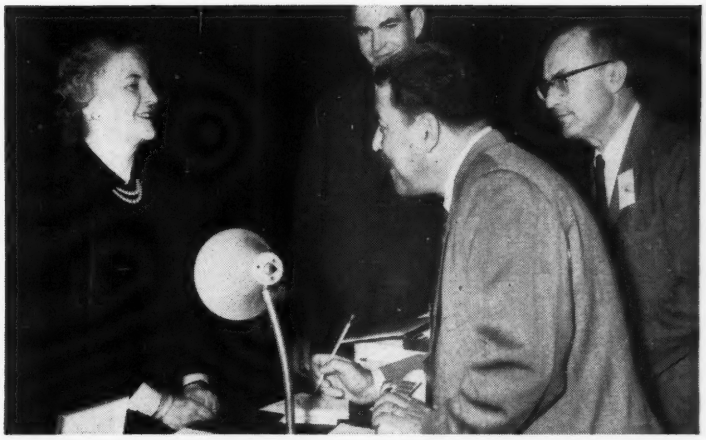

Figure 3. Dentist examining patient at close range in Dura-Blend detectability test.

The patient was displayed at the 1958 meetings of the Dental Society of the State of New York, the Massachusetts Dental Society and the Ontario Dental Society.

Lights were placed so as to give 100 foot candles illumination on the teeth. All dentists attending these meetings were eligible to participate. The patient was placed so that an examination by the dentist with his eye two feet from the patient's teeth was comfortable. The dentist was given a card on which to indicate which teeth were artificial (see Figures 2 and 3).

Results

The results of the test were tabulated separately for each of the meetings. They were so uniform that it became clear that the total for the three meetings was a statistically significant result within the limits required for this test. The results are in Table I. An answer was considered correct when the participant correctly indicated the artificial and the natural teeth. No allowance was made for chance correctness, although many participants commented that they were just guessing.

Table I

Meeting	No. of Participants	No. of Correct	% Correct
Boston	138	11	8.0
Buffalo	112	14	12.5
Toronto	104	13	12.5
TOTAL	354	38	10.7

It is safe to conclude that teeth scoring as shown, under the severe conditions described, are actually *undetectable under ordinary conditions.*

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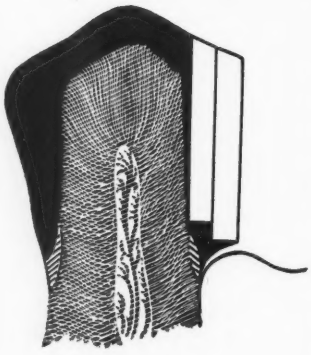

FIG. 1

Proper placement of the recess which is prepared in the abutment tooth to receive the attachment is achieved by careful preliminary planning on the study model.

In figure 1, the recess has not been made deep enough to accommodate the attachment within the normal contour of the tooth. A gingival shelf is created which is unhygienic and destructive to the investing tissue. The mesio-distal dimension is also increased which results in unfavorable leverage on the abutment tooth.

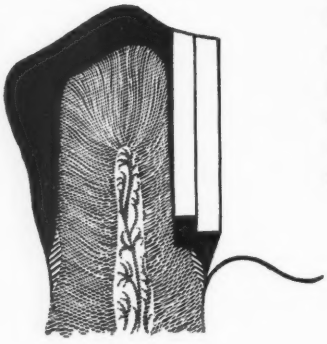

FIG. 2

Figure 2 illustrates the correct placement of the attachment within the confines of the abutment tooth, thus allowing enough room for the development of proper tooth contour.

(Prepared under the direction of competent dental authority.)

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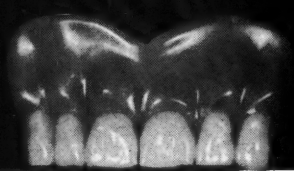

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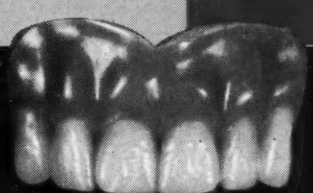

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Of all materials available to Dentistry, GOLD alone provides the characteristics required.

Because it is not chippable like other materials, GOLD is ideal for inlays. It reinforces and protects remaining tooth structure and helps to prevent breakage, decalcification and traumatic loss of restored teeth.

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GOLD is the **only** material that can be cast **accurately** enough for **fixed bridges.**

GOLD alone is available in the particular hardness required for each specific purpose.

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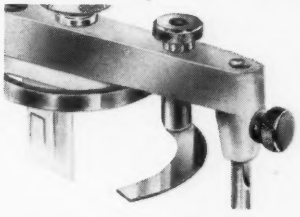
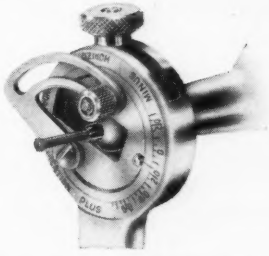
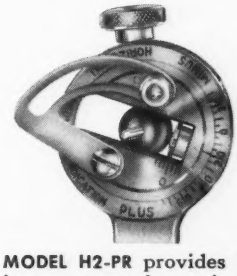


MODEL H2-O with an orbital indicator attached to the upper member of the articulator, facilitates the employment of the infra-orbital notch as an anatomical reference during facebow application and transfer.



MODEL H2-X provides special extendible condylar shafts to accommodate optional Hinge Axis Facebow transfers. These shafts, calibrated in millimeters, may be extended on either side to coincide accurately with the pointed rods of a Hinge Axis Facebow.



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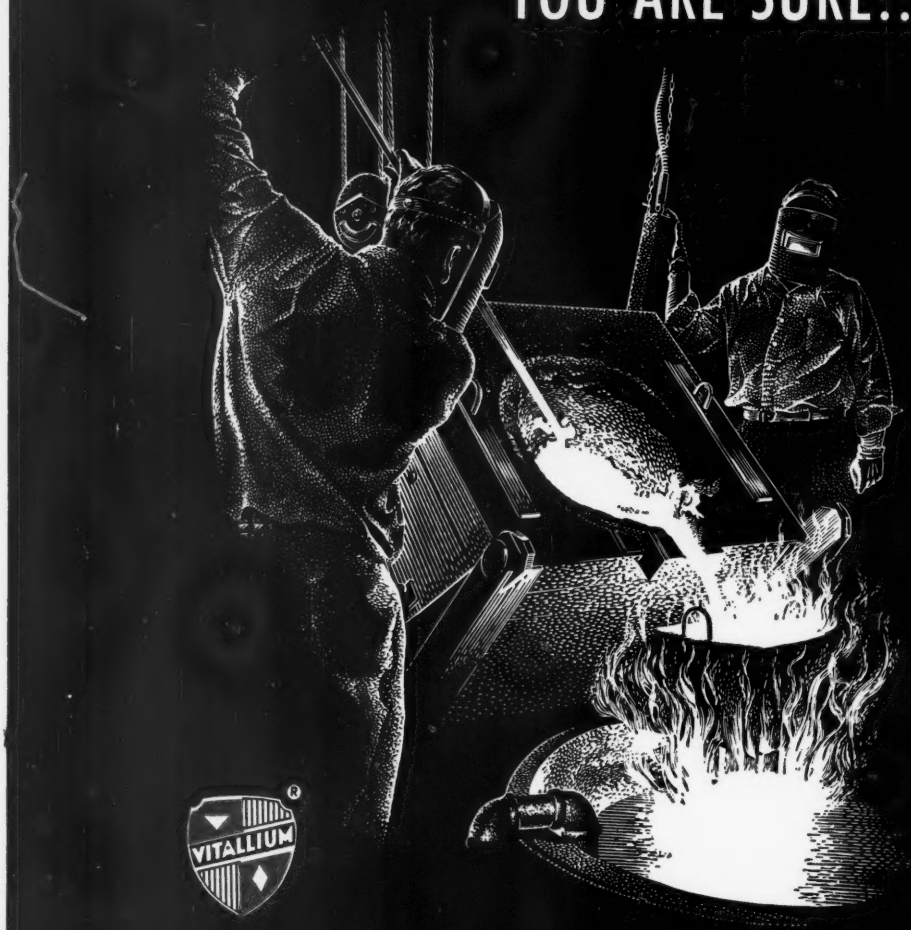

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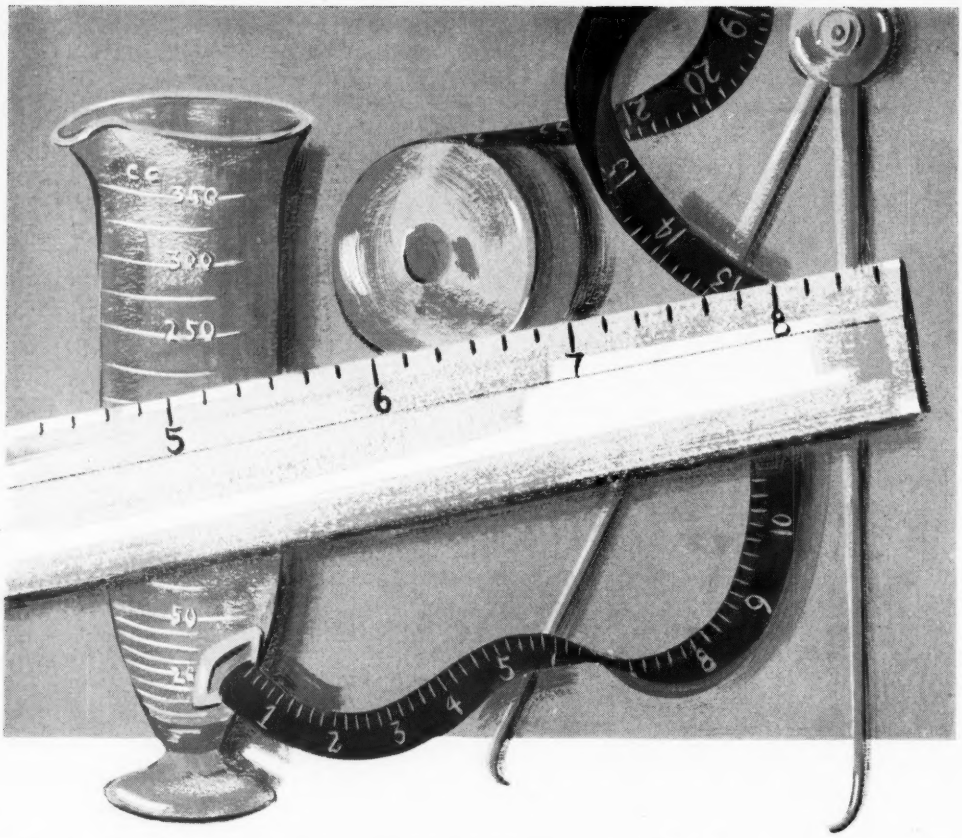

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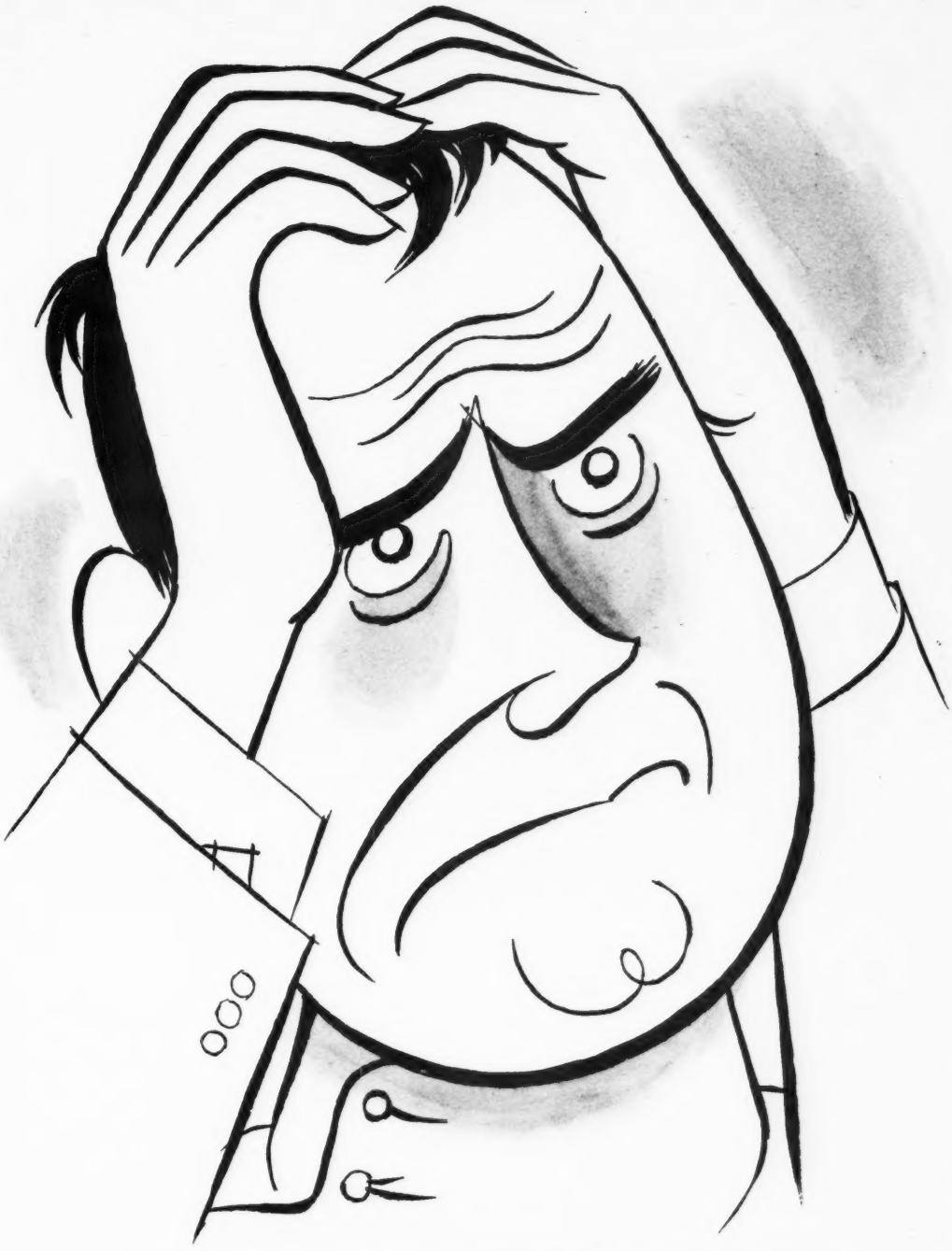

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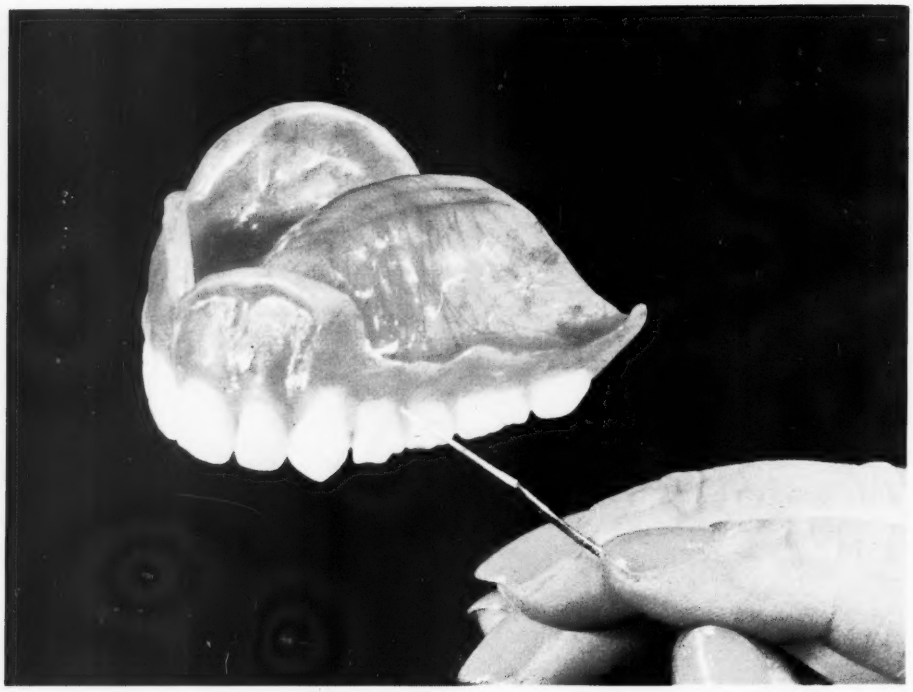

ILLUSTRATION #1

1. The unique chemical bond formed when Luxene 44 denture base material and Luxene teeth are combined in the Luxene 400 Denture excludes the infiltration of bacteria between the teeth and the base. (Illustration #1).

2. The Luxene Pressure Cast Process answers the raised bite problem by virtually eliminating the raised bite error. This accuracy of reproduction is particularly noticeable in the construction of partials. (Illustration #2).

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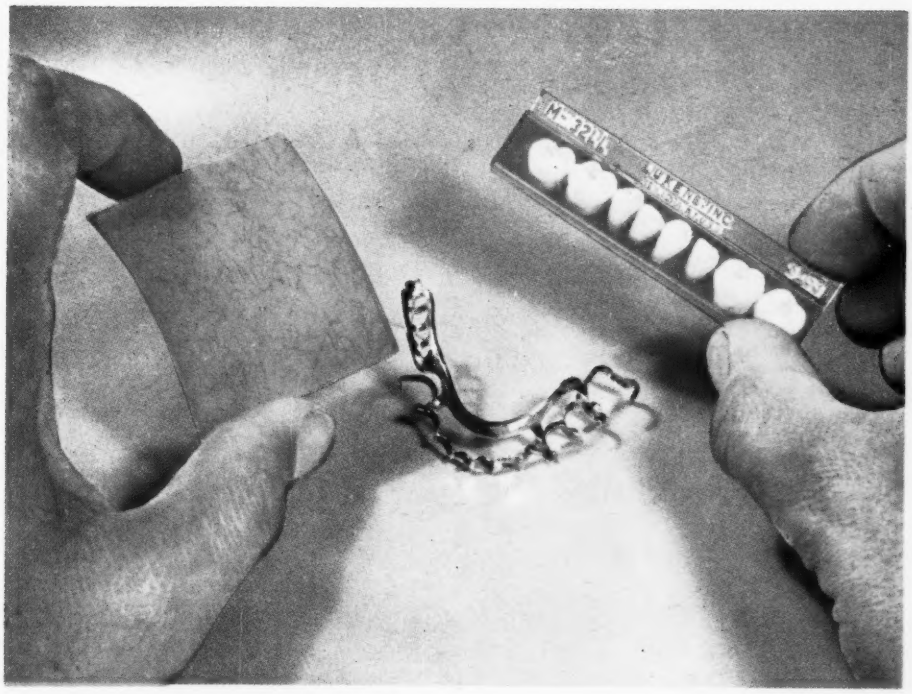
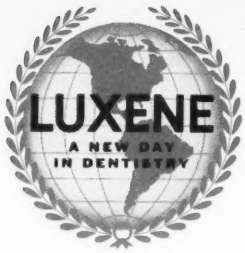


ILLUSTRATION #2

3. Luxene 400 Dentures are chemically tough and physically stable. This combination provides trouble-free service since breakage rarely, if ever, occurs.

4. Blue and red fibers are incorporated in the material to imitate veins and arteries. Oral pathologists report that this effect truly simulates Nature.



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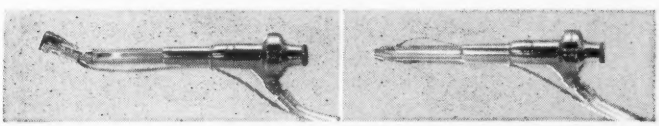

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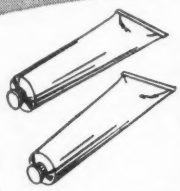

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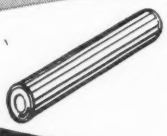

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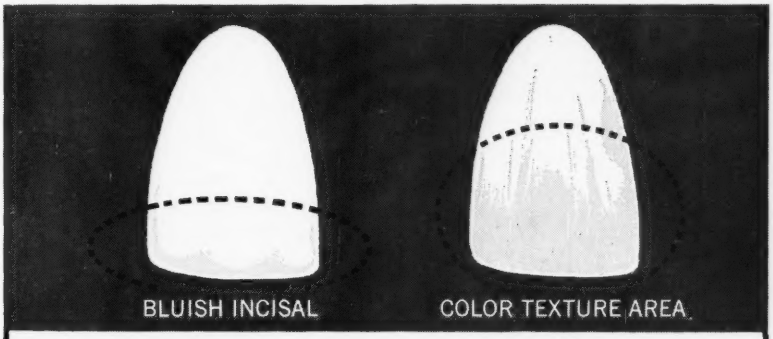

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Physiologic Shades Personality Molds Strength through vacuum-firing
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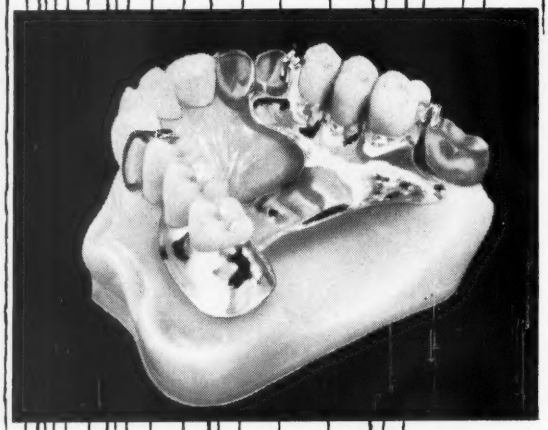

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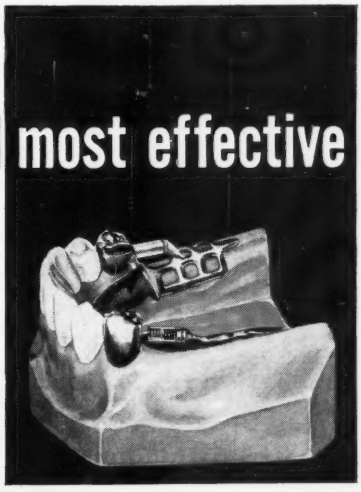

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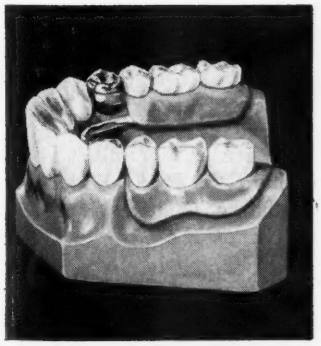

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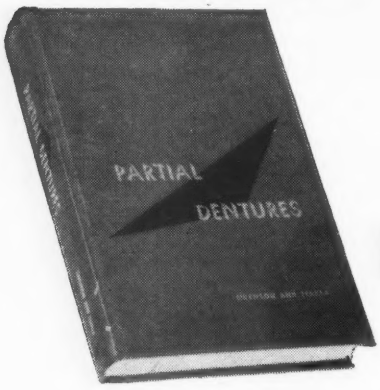

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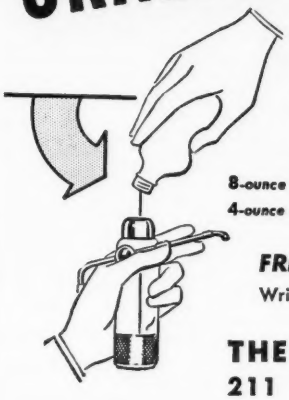

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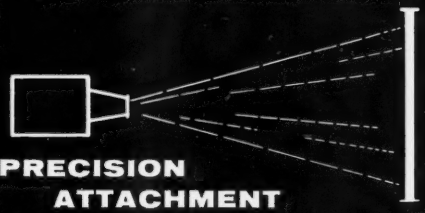

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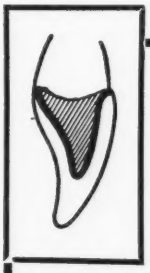

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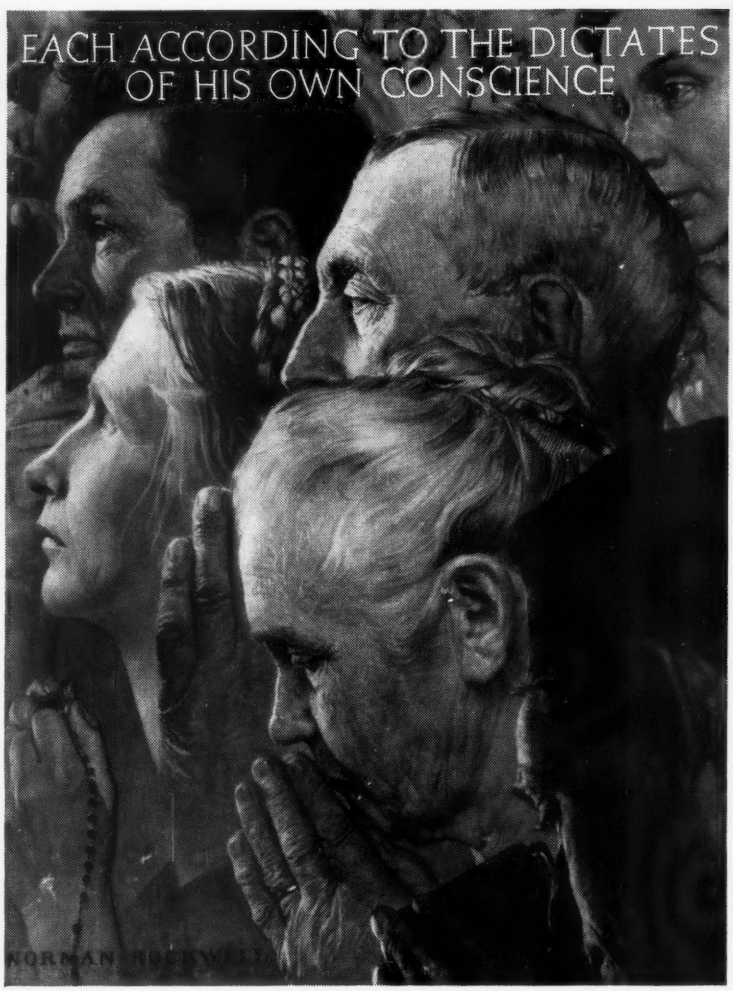

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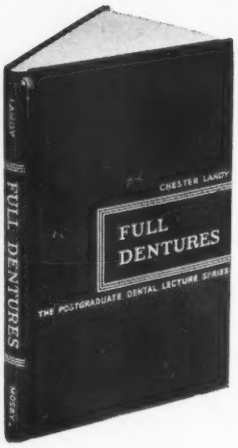

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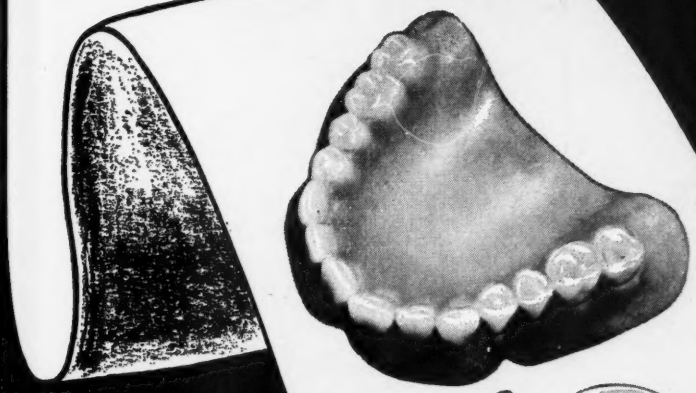

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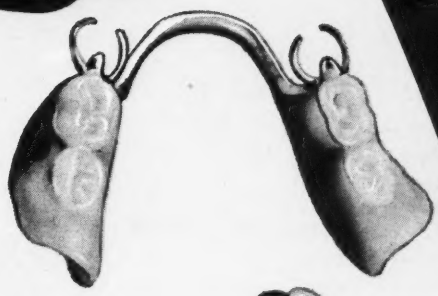

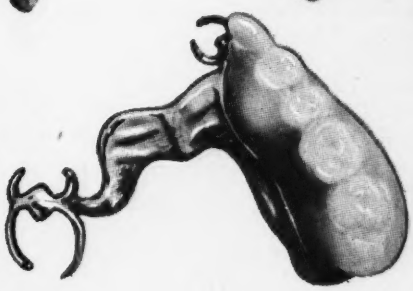

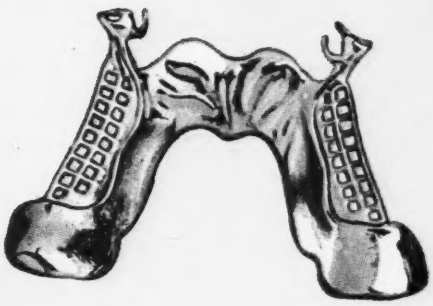

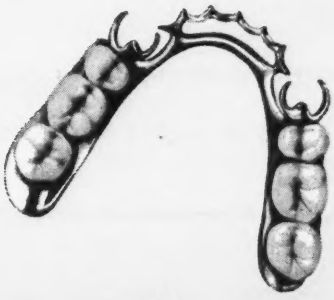

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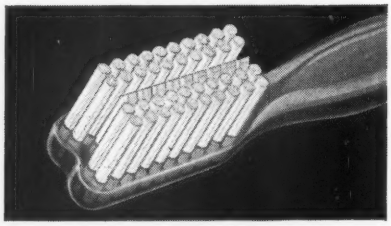

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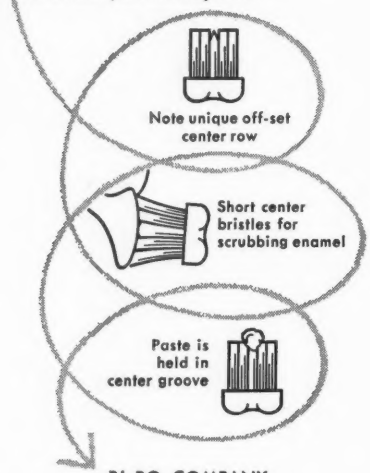

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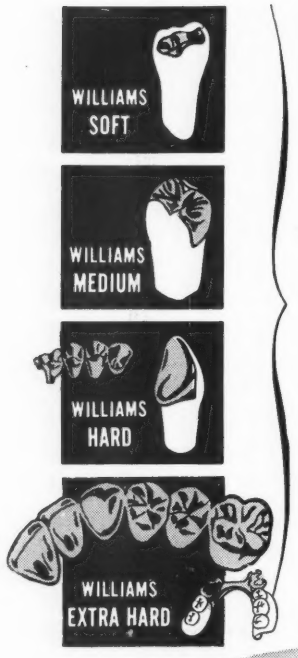

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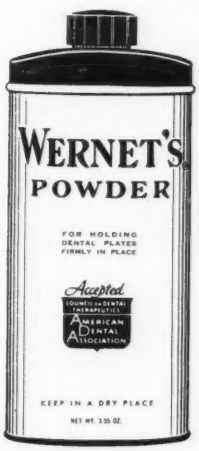

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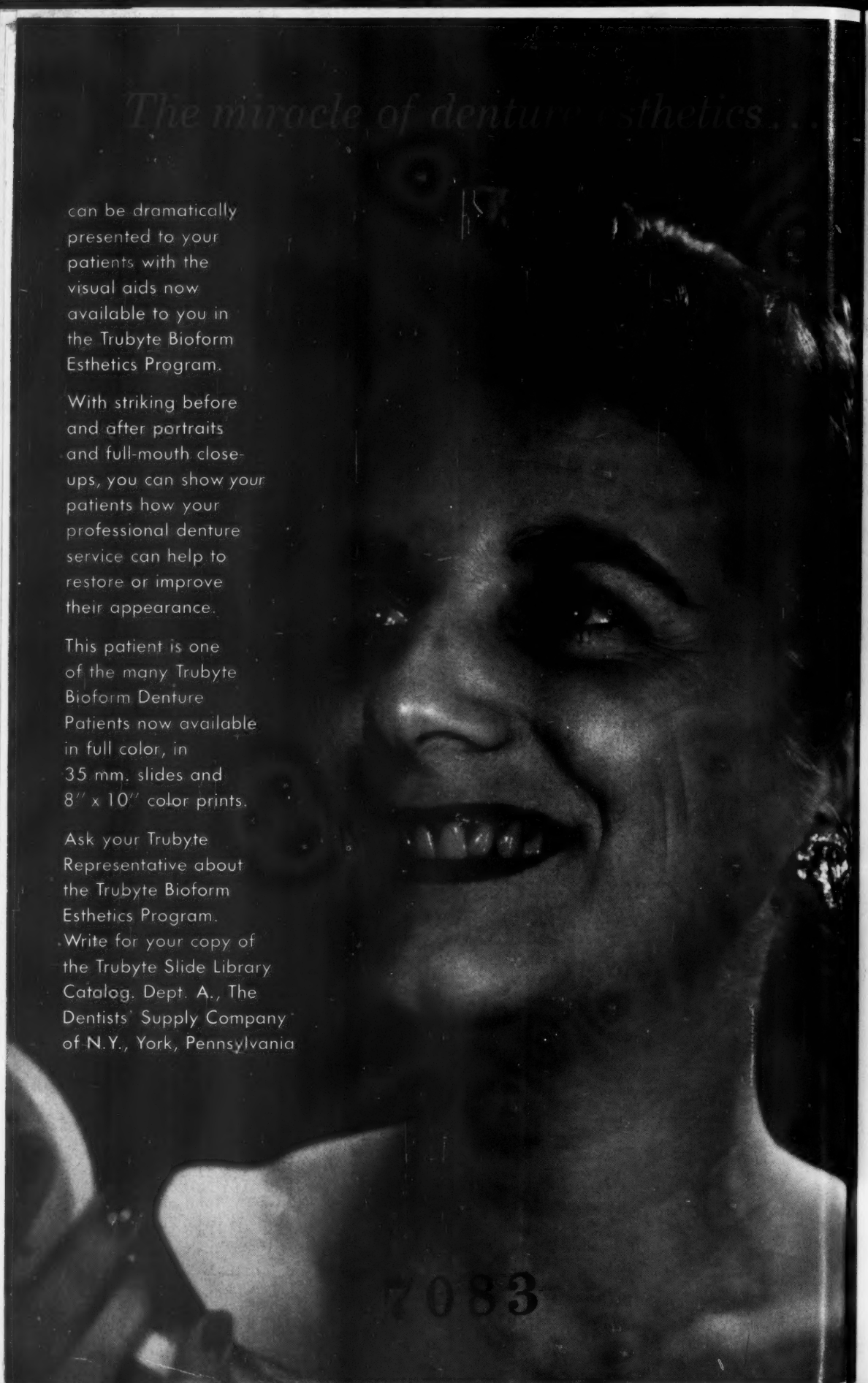
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